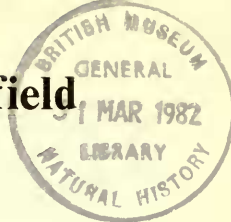


The geological researches of Dr Thomas Horsfield in Indonesia 1801–1819



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Synopsis

The American born naturalist, Dr Thomas Horsfield (1773–1859), is best known today as a zoologist, botanist, pharmacologist and ethnologist; but his geological collections were sizeable. He wrote on the chemical analyses of volcanic ash thrown out by the volcano Gunung Guntur in Java in 1803, and published papers on the mineralogy of Java and Bangka. He was a Fellow of the Geological Society of London from 1821 until his death. His greatest achievement in the geological field, however, was the production of a mineralogical map of Java in 1812.

There are no accounts of Horsfield as a geologist. An attempt is made here to describe his geological activities in Indonesia, and catalogue his surviving geological collections from Java, Bangka and Sumatra.

Introduction

Among the early nineteenth century naturalists of Indonesia the name of Dr Thomas Horsfield occupies a high and deservedly honoured place. For eighteen years between 1801 and 1819 he travelled extensively through Java studying its flora, fauna and geology, and making large and heterogeneous natural history collections which he later brought to London. He is perhaps best known today as a zoologist because of his pioneering study, *Zoological researches in Java, and the neighbouring islands* (London, 1821–24), and his work as the first Vice-Secretary of the newly established Zoological Society of London. But in Indonesia his early interests were principally in the fields of botany and geology, and while his contributions in the first of those fields were soon overshadowed by the voluminous and sumptuous publications of Carl Ludwig Blume (1796–1862), his work as a geologist remained unchallenged until the activities of Frans Wilhelm Junghuhn (1809–1864) during the 1830s, 1840s and 1850s put them in the shade. So eclipsed, indeed, were Horsfield's contributions in this field that no proper study has ever been made of

them. Yet Junghuhn, who was never prodigal in his praise of his predecessors, paid Horsfield the most generous of all tributes when he accorded to him the first place in the investigation and description of Java from a geographical-geological point of view (Junghuhn, 1853–54, I:98–99).

Horsfield's origins and scientific career in Indonesia

Thomas Horsfield was born at Bethlehem, Pennsylvania, and was baptized on 12 May 1773, the third son of Timothy Horsfield Jr (d. 1789) and Juliana Sarah Horsfield (*née* Parsons, 1738–1808). His grandfather, Timothy Horsfield Sr (1708–1773) was born in Liverpool, England, and in 1725 emigrated to New York where he settled on Long Island and learned the trade of butcher (McNair, 1942:1). In 1731 he married Mary, daughter of John Doughty, another prominent Long Island butcher, and at about the same time became influenced by Moravian doctrines^{1,2}. In 1748

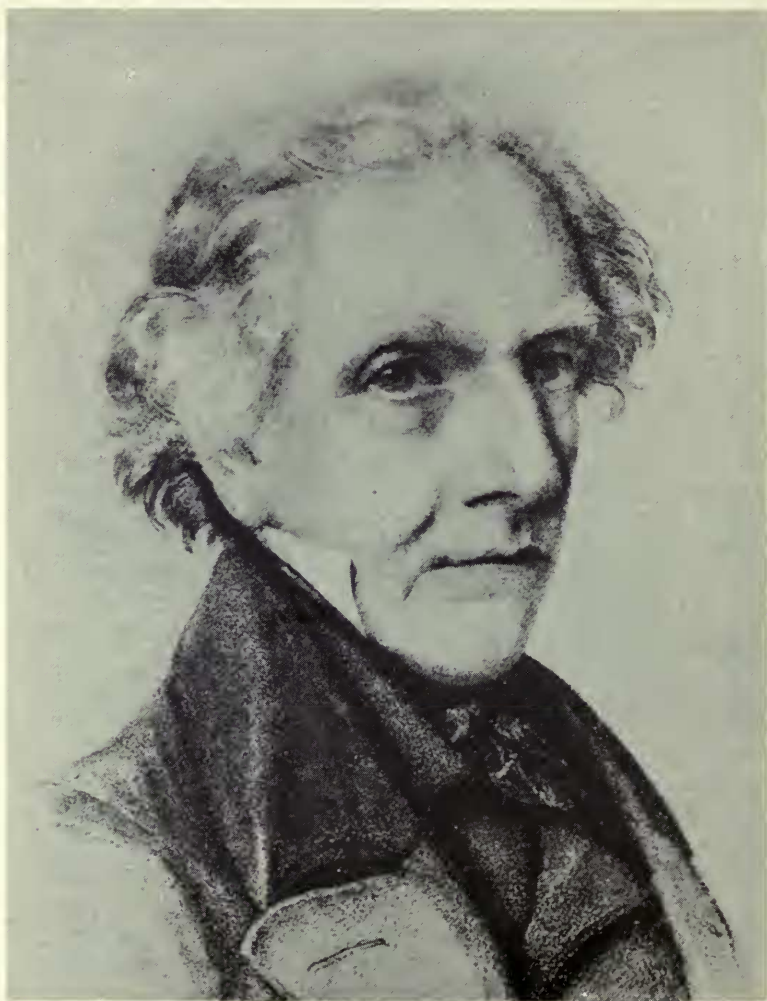


Plate 1 Dr Thomas Horsfield (1773–1859)

Reproduced from an uncoloured lithograph by the Dutch artist and lithographer, J. Erxleben, and printed by Day & Haghe, London. Erxleben was working in Leiden until his departure for England in about 1839. This, and the fact that Day & Haghe subscribe their names on the print as Lithographers to the Queen, points to the lithograph being published during the 1840s, possibly in 1843 to mark Horsfield's seventieth birthday.

he requested permission of the Moravian authorities at Bethlehem, Pennsylvania, to reside there, but because of his involvement in Moravian affairs in New York he was asked to postpone his removal. His children, however, were entered in the Bethlehem schools, and he himself moved there in the following year. He was appointed Justice of the Peace of Northampton County in 1752 and in this capacity was actively involved in the defence of the town during the Seven Years War. In 1763 he was commissioned Colonel of the forces for the defence of the frontiers of Northampton County against Indian raids, but the appointment excited some jealousy and he was obliged to resign his commission and consequently ceased to be Justice of the Peace. Some time afterwards he moved back to Long Island where he and his wife died in 1773 (McNair, 1942:1–2).

Horsfield's father, Timothy Horsfield Jr, must have stayed on in Bethlehem after his parents' return to New York since he married at Philadelphia on 14 October 1766 Juliana Sarah Parsons, daughter of William Parsons, Surveyor-General and founder of Easton, Pennsylvania (Jordan, 1909*b*:345; cf. McNair, 1942:2). She gave birth to three sons: Timothy, who died in infancy, William (1770–1845), and in May 1773, at the house in Market Street, Bethlehem (Pl.2), Thomas, the future naturalist of Indonesia (Mr V. H. Nelson, Moravian Archives, Bethlehem; Jordan, 1909*b*:345–46). Timothy Horsfield Jr died on 11 April 1789, his wife surviving him by nearly nineteen years, until 17 January 1808 (Jordan, 1909*b*:345).

Thomas Horsfield attended the Moravian schools at Bethlehem and Nazareth, and at Bethlehem appears to have learned something of the pharmacy of the day under Dr B. Otto (1711–1787) (*Dict. Am. biog.* 5 (1):236). His early interests in pharmacy and pharmacology as well as other branches of natural science were developed at the University of Pennsylvania where he may have studied under Benjamin Rush (1745–1813), James Woodhouse (1770–1809) and Dr Benjamin Smith Barton (cf. Klickstein, 1953, McNair, 1942:2). Where he gained his knowledge of chemistry is of interest since his later inorganic and analytical chemical activities in Java are discussed below. He graduated in Medicine in 1798 with a thesis entitled *An experimental dissertation on Rhus vernix, Rhus radicans and Rhus glabrum*, being a chemical description of the toxic symptoms of poisoning produced by sumac and poison ivy. A year later he was appointed Physician on the merchantman, *China*, which sailed from the Delaware River on 22 December 1799 and anchored off Batavia (Jakarta) on 15 April 1800 (Horsfield, 1805:75–85). He was so delighted with the abundance and richness of the tropical flora and other natural productions of Java that he resolved to investigate them. He returned to Philadelphia, collected books and a modest array of scientific instruments, and returned to the island in October 1801 (Horsfield *et al.* 1838–52, Postscript:i).

In order to obtain opportunities for travel and research in the natural sciences Horsfield secured appointment as Surgeon in the Netherlands colonial army. He settled initially at Batavia, but due to the unhealthiness of the place he removed to the country shortly after his arrival and carried out explorations in the Priangan Regencies. The eruption of Gunung Guntur (2249*m*) during 6–7 April 1803 turned his attention to volcanology and geology and he obtained permission to make a chemical analysis of the fall-out (Horsfield, 1814*a*). In 1804 he traversed the south-eastern ridges of Gunung Cereme (3078*m*) and visited the hot springs nearby (Horsfield, 1816*a*:41–43). He next proceeded to the south of Sumedang where he first noted the prevalence of limestone in the vicinity of the central mountain ranges of Java (Horsfield, 1816*a*:35–36). In the southern part of the regency of Parakanmuntjang he examined a well whose water, after chemical analysis, he demonstrated to possess many of the properties of European *zelzer*-water (Horsfield, 1814*d*:1–12). He explored the environs and ascended the eastern side of G. Guntur where he examined the recent lava flows. Thereafter he visited G. Tangkubanprau (2076*m*) and descended the interior walls of the crater (Horsfield, 1816*a*:19–23), collecting samples of water which he later chemically analysed.

On his return journey to Cirebon he made a detour to explore the environs of G. Tampomas (1684*m*) and the northern foothills of G. Cereme, which he had skirted earlier. Travelling along the northern coast of Java, he observed G. Sundara (3135*m*), G. Sumbing (3371*m*) and G. Prau (2565*m*), south-east of Pekalongan, all of which, with the exception of G. Sumbing, he was later to climb. He left Serondol in December 1804 for Ungaran, making a detour to climb G. Ungaran



Plate 2 Horsfield House at 42 W. Market Street, Bethlehem, Pennsylvania. Built in 1749 by Horsfield's grandfather as a family residence, it was later used as a general store and trading place when an addition was erected in 1755. Horsfield was born in the house in May 1773.

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(2050m). Close to its summit he examined the remains of an extinct crater in which he found traces of a sulphurous lake similar to those of G. Tangkuban-prau. He also examined on its slopes, and in its immediate surrounds, a number of mineral wells. He proceeded to Salatiga and on to G. Merbabu (3142m), which he partly ascended. He then visited Sela, situated on the northern slopes of G. Merapi (2911m), the principal volcano of central Java which had erupted with such violence in 1803 that a large portion of the top had collapsed, altering the shape of the mountain. It is unlikely that he climbed to its summit on this occasion, though the matter is confused by a later statement he made on the subject (Horsfield *et al.*, 1838–52, Postscript:ii).

After July 1805 Horsfield journeyed to Jogjakarta (Horsfield *et al.*, 1838–52, Postscript:ii) with the object of investigating the range of hills which run along the southern coast of Java. In August he visited Surakarta and made an excursion to G. Lawu (3265m), ascending its eastern side and discovering an extinct crater and another which emitted fumes through apertures in the crust. In October 1805 he proceeded northwards towards Grobogan and Blora with the intention of investigating the salt wells which cover an area of several miles and furnish the Indonesians with mineral and saline waters for medicinal use. He then travelled along the Solo river to Gresik, and on to Surabaya whence he set off on a hurried visit to the Tengger mountains. After climbing G. Bromo (2392m) he returned in January 1806 to Surabaya where he remained for three months, meeting during his stay the French naturalist, J. B. L. C. Th. Leschenault de la Tour (1773–1826),

one of the naturalists on Baudin's voyage to Australia, who had visited G. Idjen in east Java during September 1805 and the Tengger mountains during November of the same year, thus anticipating Horsfield's visit by a little more than a month (Van Steenis-Kruseman, 1950:321–22).

Horsfield left Surabaya in April 1806 for Prabalingga, making a brief detour to examine the mud wells near Buntidan (Horsfield, *et al.* 1838–52, Postscript:iii–iv). He explored the eastern side of G. Semeru (3676m) and although he did not ascend to its peak he climbed along one of its ridges far enough to obtain an external view of its crater (Horsfield, 1814c:18–19). At Lumajang he was able to observe G. Lamongan (1600m) which was showing signs of activity (Horsfield *et al.*, 1838–52, Postscript:iv). In June he set out for Puger and journeyed northwards towards Jember and the plain bounded on the north-west by the Ijang range of mountains and on the east by G. Raung (3332m) (Horsfield, 1814b:20). He then proceeded to Bandawasa and on to Panarukan to the east of G. Ringgit (1250m) (Horsfield *et al.*, 1838–52, Postscript:iv). From Panarukan he travelled to Banyuwangi where he spent more than two months making local excursions. He ascended G. Merapi (2800m) and examined its crater, and at about the same time he crossed the Straits and spent one day in Bali (Horsfield *et al.* 1838–52, Postscript:vi). In October 1806 he set off on the return journey to Pasuruhan, via Panarukan, Besuki and Prabalingga, and again explored the Tengger mountains during December (Horsfield, 1814c:30). In January 1807 he visited Malang and Bangil, and after taking profiles of G. Arjuna (3339m) and G. Pananggungan (1653m), he arrived at Surabaya in early February, where he remained for some time, visiting briefly Madura. Thereafter he journeyed along the coast to Semarang, which he reached in August 1807 (Horsfield *et al.* 1838–52, Postscript:vi).

Horsfield remained in the neighbourhood of Semarang during the rest of 1807 and for most of 1808 before proceeding early in 1809 to Prawata in Demak and on to Surakarta, which became his principal residence during the remainder of his stay in Java. In 1810 he returned to G. Merapi and G. Merbabu which he had partly surveyed five years previously. This time he ascended G. Merapi making a minute examination of its crater. He also investigated the southern ridges of G. Merbabu, and in 1811 the country between the western ridges of G. Lawu and the eastern boundary of Mataram. On 5 June 1811 he witnessed the eruption of G. Kelut (1731m) (Horsfield, 1816a:23). The capture of Java by the British later that year gave additional stimulus to his researches³ for he now received the formal patronage of the British Lieutenant-Governor, Thomas Stamford Raffles (1781–1826), who encouraged him to extend his enquiries to all branches of natural history (Lady Raffles, 1830:603). His geological researches bore fruit when, with Raffles' support, he published a series of papers in Volumes VII and VIII of the *Verhandelingen van het Bataviaasch Genootschap der Kunsten en Wetenschappen*, including the important work, 'On the mineralogy of Java' (Horsfield, 1816a).

In 1812 Horsfield obtained permission to carry out investigations in west Java and he left Surakarta in September of that year (Horsfield *et al.*, 1838–52, Postscript:vii). In Batavia he was prevailed upon by Raffles to join a Commission which was about to proceed to P. Bangka to enquire into its affairs and resources and he spent some nine months travelling throughout the island and investigating the tin mines worked by Chinese labour (Horsfield, 1848:299–336, 373–427, 705–25, 779–824; Horsfield *et al.*, 1838–52, Postscript:vii–ix). He arrived back in Java in July 1813 and after a brief interlude at Buitenzorg (Bogor) he settled again at Surakarta, where he spent several months preparing his geographical and mineralogical description of Bangka for submission to Raffles. In August of the following year he visited Jogyakarta before proceeding southwards to Karang Bolong and on to Banyumas, returning to Surakarta in early November (Horsfield *et al.*, 1838–52, Postscript:x; Horsfield, 1816b:1–48). In mid-1815 he made another trip into eastern Java, visiting Kediri and G. Kelut, which he ascended with a party of Indonesians before returning to Surakarta in November of that year (Horsfield *et al.*, 1838–52, Postscript:xii–xiii). In 1816 he explored the regions of central Java, visiting G. Prau in October, and later G. Merapi.

The same year saw the restitution of Java and its dependencies to the Netherlands, but Horsfield was assured of the continuing protection and support of the new government for his scientific activities. In 1817 he conducted further surveys of the regions around Surakarta, and in the early part of 1818 he visited Bogor in west Java, and Batavia, where he received an invitation

from Raffles, now Lieutenant-Governor of Fort Marlborough, to join him in west Sumatra. As a consequence, Horsfield proceeded to Semarang to load his natural history collections on board the *Lady Raffles* (Captain H. Auber), which carried him to Benkulen at the end of June 1818. In the following month he accompanied Raffles and his wife on a journey from Padang to Pagarruyung in central Sumatra (*Lady Raffles*, 1830:340–65). In August 1818 he returned to Batavia, and travelled through Banten to G. Karang (1778m) and on to Cianjur, G. Gede, and through northern Java to Semarang. With his natural history collections on board the *Lady Raffles* he sailed for England in January 1819, arriving at Portsmouth on 12 July of that year.

Horsfield's later years in England

Horsfield was engaged by the Directors of the East India Company⁴ to arrange his collections in the Company's Museum in Leadenhall Street, and to act as curator of the Museum under Sir Charles Wilkins (1749–1836), who had responsibility for both it and the Library. Horsfield was paid a fee of one guinea a day for his services, but after Wilkins' death the administration of the Museum and Library was divided and he was placed in full charge of the former on an allowance of £500 per annum (Arberry, 1967:48–49, 57). The work of Keeper of the Museum does not appear to have been arduous (visitors to the Museum being restricted to Fridays), and Horsfield was thus enabled to pursue with minimum interruption his own researches and writing. Between 1821 and 1824 his large quarto work, *Zoological researches in Java, and the neighbouring islands*, was published, and this was followed in 1825 by W. S. Macleay's *Annulosa Javanica*, an account of the insects collected by Horsfield in Java and deposited by him in the East India Company Museum. Horsfield's *Descriptive catalogue* of his collection of Indonesian lepidoptera in the same Museum was published between 1828 and 1829. Later, following the appointment in 1848 of Frederick Moore (1830–1907) as Assistant in the Museum, he produced in collaboration with him comprehensive catalogues of the lepidopterous insects and birds in the Museum (Cowan, 1975:273–84).

Horsfield was elected a Fellow of the Linnean Society of London in 1820 and a Fellow of the Royal Society in 1828. He took an active part in the deliberations of the Zoological Club of the Linnean Society which led to the formation of the Zoological Society of London (Bastin, 1970; Bastin, 1973), and he acted as the first Vice-Secretary of the Zoological Society between 1826 and 1828. He joined the Geological Society of London in 1821 and served on its Council from 1823 to 1826 during the time when the Charter was under negotiation. He was also a member of the Geological Society Club which consisted of members who dined together on meeting days. During the mid-1820s he was living at 6 Castle Street, Holborn, and during the late 1820s and early 1830s at 2 Raymond Buildings, Gray's Inn. From at least 1835 until 1849 (judging by the lists of Fellows of the Geological Society) he was resident at 20 Stonefield Street, Islington, and thereafter at 29 Chalcot Villas, Adelaide Road, Camden Town, where he died on 24 July 1859, aged eighty-seven years. He was buried at the Moravian Church burial ground at Chelsea five days later, and his grave in the western plot of the cemetery still survives⁵. He was a life-long member of the Moravian Church and had been admitted to the London Congregation in Fetter Lane in December 1820 (Diary, volume 22, 1817–28, of the London Moravian Congregation). His obituary notice in the *Proceedings of the Royal Society* (X 1860:xxi) describes him as a man 'of retired habits, but of amiable character and unblemished integrity'.

As a naturalist Horsfield's interests were unusually wide. His initial scientific interests in Indonesia were in botany (principally *materia medica*) and geology, but he later broadened the scope of his enquiries to include zoology, entomology and ornithology. These latter fields increasingly engaged his attention and because of his involvement in the affairs of the Zoological Club of the Linnean Society and the newly formed Zoological Society, and also because of his publications on zoological subjects, he became known primarily as a zoologist. He himself recognized the fact though he continued for nearly thirty years to be associated with Robert Brown and J. J. Bennett in the publication of *Plantae Javanicae Rariores* (Horsfield *et al.*, 1838–52). Geology for Horsfield was never a major interest, though he showed himself to be a reasonable observer. His numerous and extensive excursions in Java enabled him to build up a geological

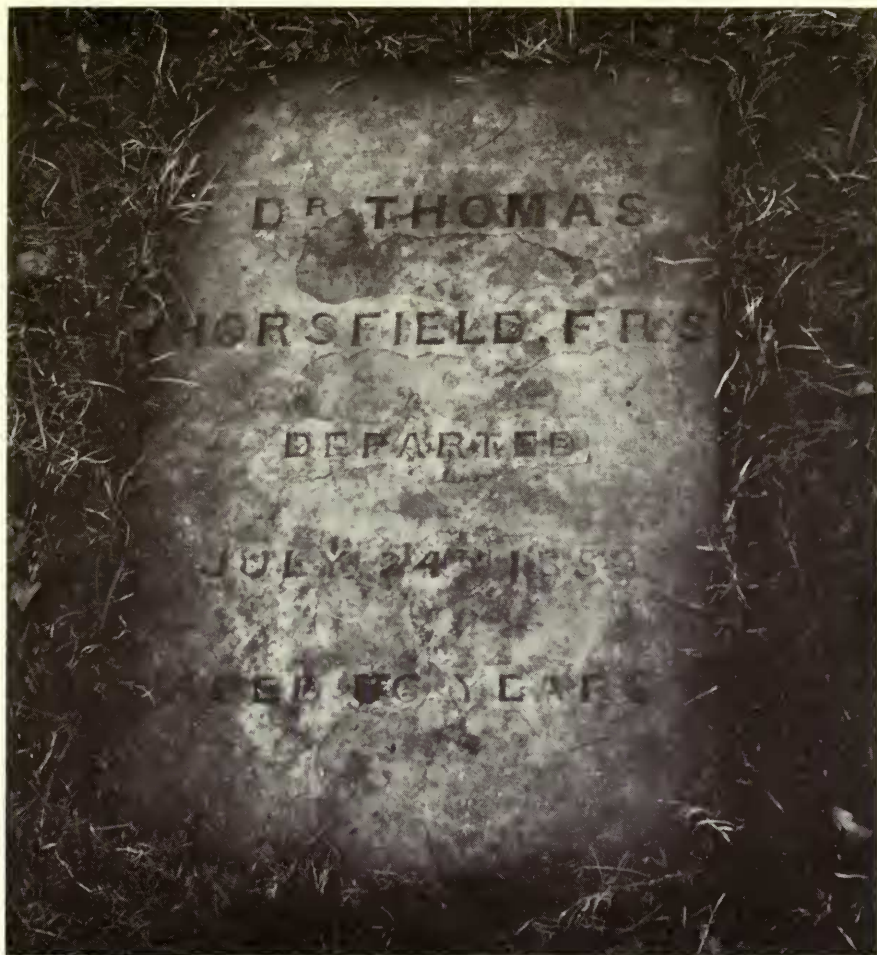


Plate 3 Horsfield's memorial stone in the Moravian Church burial ground at Chelsea, London.

picture of the island which he published in 1816. From his detailed account of the volcanoes of Java he understood that they formed a more or less uninterrupted east-west chain, and he commented on them at some length in his early publications (Horsfield, 1814*b*; Horsfield, 1816*a*; Horsfield, 1816*b*). Limestone ranges, alluvial plains, mud wells, hot springs, and wells of petroleum or naphtha were also commented on. Horsfield never theorized on geological matters, although he was well read on the subject⁶, and was aware of Werner's views, and those of the Plutonists. But his greatest achievement was unquestionably the compilation of the mineralogical map of Java and, a similar map of Bangka.

Catalogue of rock specimens collected by Horsfield in Java

Four versions of a catalogue of geological specimens collected in Java by Horsfield exist in the India Office Library and Records, London (*MSS. Eur. F. 53*). Three are in Horsfield's handwriting and the fourth is in that of one of his scribes. We learn from these manuscripts that 366 collecting localities were visited by Horsfield in Java during his eighteen years' stay in the island, though only representatives of localities 1–273 are contained in the collection of his rock specimens in the Department of Mineralogy, British Museum (Natural History). Two manuscript versions of the catalogue of rock specimens made by Horsfield also exist in the Department of

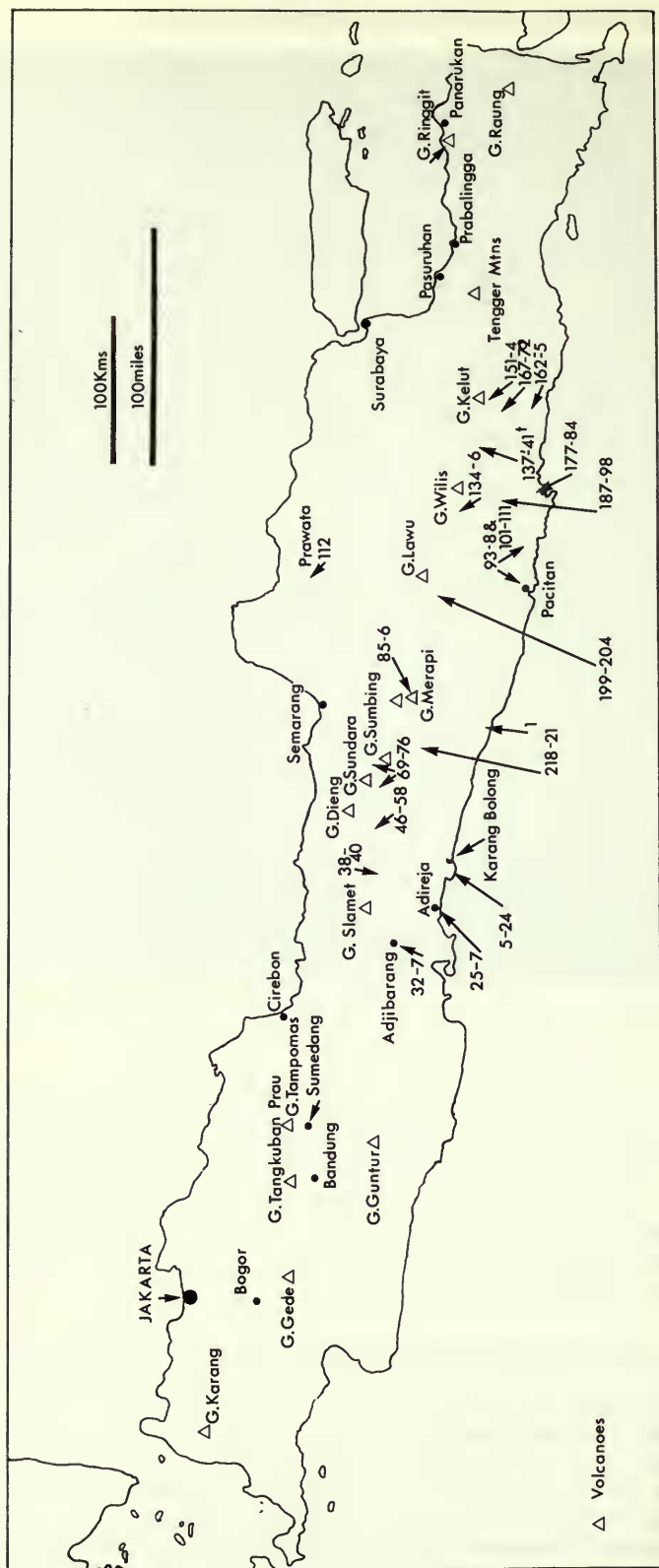


Fig. 1 Sketch-map showing the approximate collecting localities (numbered) of Horsfield's surviving geological specimens from Java.
For details of specimens see catalogue.

Mineralogy Library, British Museum (Natural History), handed over in 1879 by the India Museum with some 4500 rock specimens collected in India and elsewhere. A part of these catalogues, corresponding with specimens 1–77, was published in 1816 (Horsfield, 1816b:156–63). The first and complete version of the catalogue was written by a scribe and signed by Horsfield at Surakarta on 31 May 1816. It lists specimens 1–216. A continuation signed by Horsfield is undated and lists specimens 217–273. The second (incomplete) version of the catalogue, listing specimens 115–207, is also signed by Horsfield and dated Surakarta 8 December 1815. It is addressed and dedicated to Raffles. Specimens 1–77 were collected between August and November 1814, and specimens 78–273 during the same period and beyond to at least 1816.

Unfortunately, none of these catalogues contains information on the dates or circumstances of collection. An edited version of the fullest of the manuscript catalogues in the India Office Library and Records (*MSS. Eur. F. 53*) is given below. The number in the catalogue refers to a locality, not to a specimen, and there may be one or more specimens per locality. The British Museum (Natural history) number is given, together with some petrographic notes, and taxonomic notes in the case of the fossil specimens. Correlation of the specimens and the catalogue is relatively simple as Horsfield's number is attached to the specimens, together with the British Museum number. The latter number was given when the collection was registered at the British Museum (Natural History) probably in 1893, and bears no relation to Horsfield's numbers. The British Museum numbers appear to have been assigned in ignorance of the text of the catalogue. In the version of the catalogue printed below Horsfield's spelling and other idiosyncrasies have been preserved, but certain of his petrographical and geological terms must first be commented on, as their usage conflicts with contemporary practice.

Amygdaloid: an amygdaloidal lava in contemporary usage. See Johanssen (1931–8, 3:281). Horsfield, however, sometimes uses the term to mean a lumpy or heterogeneous rock, see *Puddingstone*.

Basalt: a basic lava, see Johanssen (1931–38, 3:246). To Horsfield basalt probably meant a black crystalline fine-grained lava.

Burning volcanoes: a Neptunist concept. The Neptunists believed that volcanoes were the product of burning underground coal seams.

Calcined basalt: The word calcined is used by Aikin and Aikin (1807:177) to mean an oxide, the term being derived from 'calx' of the alchemists. Horsfield uses the term to mean a whitened or weathered rock.

Floetz or *Flötz*: a Neptunist term, approximating in palaeontological terms to Mesozoic.

Greenstone: a metamorphosed basic rock, rich in green minerals, e.g. chlorite and amphibole.

Hornstone: a siliceous rock having a sub-conchoidal fracture (Holmes, 1920).

Lava: an extrusive and fine-grained igneous rock. To the Neptunists lava was a rock distinct from basalt.

Puddingstone: a conglomerate. Horsfield sometimes uses the word amygdaloid in the same sense.

Stone of watery deposition: sedimentary rock.

Trapp or *Trap*: originally a Swedish word, applied to igneous rocks which were neither coarsely crystalline nor fine-grained and volcanic. See Holmes (1920), and Johanssen (1931–38). Horsfield uses the word in the above sense.

Trachyte: The word was first used by R. J. Haüy (1743–1822) in 1822, being derived from *Τραχυνός* to mean volcanic rock of rough appearance (Johanssen, 1931–38, 3:67). Horsfield *et al.*, (1838–52 Preface:iii–iv) uses the word in this sense.

Tufa: a calcareous deposit from springwater. Horsfield, however, uses the term to mean tuff, which is a pyroclastic rock.

The history of petrological nomenclature is a study of its own, and space prohibits more than the note above, but Johanssen (1931–38) points out that many of these old names disappeared in the nineteenth century with the introduction of the petrological microscope and thin section making, when the evolution of the contemporary petrological classification based on the mineralogy of rocks began. Further, many of Horsfield's rock specimens are weathered, and not what a contemporary geologist would collect. In the catalogue which follows, weathered specimens have

not been sectioned and the catalogue is simply annotated to the effect that the specimen is weathered.

Catalogue of explanatory specimens [this is the title of Horsfield's (1816b) printed account, the MS title continues:] *to illustrate the mineralogy of the territory of the native princes of Java.*

Horsfield's (1816b) account lists specimens 1–77 but due to the size of the MS catalogue the printed entries, where the specimens no longer exist in the collection of the British Museum (Natural History), are not listed as reference can be made to Horsfield's publication, where some field notes are also recorded. From 78 onwards all the entries are listed and annotated. See also Fig. 1.

1. *Pebbles from the river Progo* [Praga], near Brossot [Brasat]
[Specimen BM 73260, a water-worn pebble of pyroxene-hornblende andesite. Collected in August 1814.]
[Specimens 2–3 missing]
4. *Hornstone-rock from the eminence over Guwo-Duhar* [Guwa Duhar] called *Karang-Kuda*
[BM 73225, limestone. See Horsfield, 1816b:94–96.]
5. *Puddingstone from the cavern of Karang-bollong* [Karang Bolong] near the extremity of the hill, at the discharge of the river *Tshitshing-goleng* [Cincingguling], from which the village and settlement has derived its name
[No BM number, the specimen is a coarse conglomerate of igneous cobbles. Collected August 1814. See Horsfield, 1816b:92.]
[Specimen 6 missing]
7. *Stone of watery deposition, lamellar, nodular &c from the eminence between the discharge of the river Tshitshing-goleng* [Cincingguling] and the village *Karang-bollong* [Karang Bolong]
[BM 73315, pyroxene andesite. See Horsfield, 1816b:92–93. Collected August 1814.]
8. *Calcareous stone found in large piles on the hill above Guwo Nagassari* [Guwa Nagasari]
[BM 73346, white fossiliferous limestone, bearing gastropod traces. Horsfield (1816b:97–99) states that the limestone above the cave contained numerous shells. Dr C. P. Nuttall of the Department of Palaeontology, British Museum (Natural History) states that the fossil is a holostomatous gastropod, possibly belonging to the fresh water family Thiariidae. According to the Geological Map of central Java 1: 500,000 (1977 ed.), the Karangbata peninsula is composed of Miocene sedimentary rocks.]
[Specimen 9 is missing]
10. *White friable semi-decomposed lava (denominated Padas by the natives belonging to the substance named Tufa) found copiously on the hills on the route from Karang-bollong* [Karang Bolong] to *Dshittis* [Jetis]: (Similar to n° 7.)
[BM 73171, yellow quartzite. Collected August 1814.]
11. *Same substance (n° 10) more compact-forming Sandstone found on the same route*
[BM 73427, quartz conglomerate.]
12. *Hornstone-porphry from the shore near Dshingkla* [Cingkla]
[BM 73309, weathered lava.]
[Specimens 13–17 missing]
18. *Cavernous lava from Udshung-agung* [Ujung-agung] on *Nuso Brambang* [Nusa Brambang]
[BM number obscure, but the specimen is a pyroxene- and zeolite-bearing lava. See Horsfield, 1816b:107–109.]
[Specimens 19–22 missing]
23. *Calcareous stone from the foot of the hill near Karang-bolo* [Karang Bolong], from the same
[BM 73175, amygdaloidal pyroxene-bearing lava, now much replaced by calcite. See Horsfield, 1816b:110.]
24. *Basaltic stones from the rivulet near the village Brambang—from the same*
[BM 73330, vesicular andesite.]
25. *Sand-stone, from an extensive stratum at banks of the river Adiradsha* [Adireja] in the district of *Aya* [Ayah]

- [BM 73314, hornblende-pyroxene andesite much replaced by calcite. See Horsfield, 1816b:110.]
26. *Cavernous lava from the discharge of the river Adirodsho* [Adireja]—*near the village Sawangan*
[Two specimens. BM 73207 and BM 73297 are hornblende andesites. See Horsfield, 1816b:111.]
27. *Lava separating into Rhomboidal fragments from the foot of the hill Bedagangan* [Pedagangan]
opposite the village of Adiradsha [Adireja], *found at the banks of the river*
[Two specimens. BM 73290, and 73392 are grey weathered lava.]
28. *Volcanic tufa—Padas—of the Javanese from Suko-rosho* [Sukaraja]
[BM 73319, agglomerate. See Horsfield, 1816b:112–13.]
[Specimen 29 missing]
30. *Lavas from the basin of the river Bandsharan* [Banjaran] *arising from the foot of the mountain of Tagal* [G. Slamet]
[Two specimens. BM 73183 and BM 73223 are basalts with phenocrysts of plagioclase and pyroxene. See Horsfield, 1816b:114. G. Slamet (3428m) produces pyroxene basalts and andesites (Neumann van Padang, 1951).]
31. *Lavas from the river Lo-Gowak* [Lo-Gowok] *arising from the same mountain*
[Two specimens. BM 73267, dark vesicular pyroxene basalt. BM 73337 is a vesicular, but different, lava. Horsfield, 1816b:114–15.]
32. *Lavas from the river Datar near Adshibarang* [Adjibarang]
[BM 73191, grey vesicular basalt with phenocrysts as above. Horsfield was in this area in September 1814. See Horsfield, 1816b:116.]
33. *Lavas from the declivity south of Adshibarang* [Adjibarang] *and from various other situations in the neighbourhood of that village*
[Two specimens. BM 73341, dark vesicular basalt, as above. BM 73193 is dense porphyritic lava. Locality referred to in Horsfield, 1816b:116 as ‘an extensive channel of compact lava’ in the river Datar. Collected September 1814.]
34. *Stone of watery deposition from a hill south-west of Adshibarang* [Adjibarang] *near the banks of the river Tiaddshum* [Tajem]
[BM 73232, grey sandy microfossiliferous limestone. See Horsfield, 1816b:118–119.]
35. *Varieties of stone of watery deposition from the same place (N° 34) in lamellar, nodules &c &c*
[BM 73340, microfossiliferous feldspathic grit, containing planktonic foraminera of Tertiary age, according to Dr J. E. P. Whittaker. See Horsfield, 1816b:120.]
36. *Sandstone from the same place*
[BM 73215, fine-grained grit. See Horsfield 1816b:120.]
37. *Rock from the banks of the river Tiadshum* [Tajem] (*resembling Amygdaloid*), *near Adshibarang* [Adjibarang]
[BM 73369, veined limestone. Localities 34–37 referred to in Horsfield, 1816b:118–19.]
38. *Lavas from the road towards Bodshing-Tongo* [Bejing-Tongo?] *in the district [of] Probolingo* [Purbalingga]
[Two specimens. BM 73261, pyroxene basalt. BM 73324 is vesicular lava. Horsfield was in this area in September 1814.]
39. *Varieties of Tufa from the river Kelawing near Probolingo* [Purbalingga]
[BM 73282, agglomerate. See Horsfield 1816b:121–22.]
40. *Various siliceous stones out of the same*
[Three specimens. BM 73405, greenish quartz tuff. BM 73204 is greenish yellow chert, and BM 73303 is reddish mottled jasper.]
41. *Tufa from Kumutuk* [Kemutug]
[BM 73333, agglomerate. See Horsfield, 1816b:121.]
42. *Compact lava, from the same place*
[Two specimens. BM 73165, grey basalt with phenocrysts of pyroxene and plagioclase. BM 73164 is grey vesicular lava (unsectioned). See Horsfield 1816b:121. The specimens came from a rivulet. Collected October 1814.]
[Specimen 43 missing]

44. *Rounded volcanic pebbles, from the same place*
[BM 73291, hornblende andesite pebble. See Horsfield, 1816b:126.]
[Specimen 45 missing]
46. *Fragments from the large piles composing Gunung Lawet consisting of tabular &c Basaltes* [sic]
[BM 73322, pyroxene-hornblende andesite. See Horsfield, 1816b:127–29.]
47. *Sandstone from the foot of the same (see N° 46)*
[BM 73231, grey calcite-bearing grit. See Horsfield, 1816b:130–31.]
48. *Stones of watery deposition from the foot of the hill Pawinian, on the route from Bandshar [Banjar] to Pagger-pella [Pagerpelah]*
[Three specimens. BM 73389, reddish sandstone with a weathered crust. BM 73224 is calcareous shale, and BM 73361 is yellow sandstone. Horsfield passed this way in October 1814. Some notes on the field occurrence are given in Horsfield, 1816b:132–33.]
[Specimen 49 missing]
50. *Basaltes* [sic] *in a state of decomposition from the northern declivity of the eminence of Pagger-pella [Pagerpelah] on the road towards Karang-kobar*
[BM 73245, agglomerate or lithic tuff. See Horsfield, 1816b:133.]
51. *Varieties of original Basaltes* [sic] *from the same*
[Two specimens. BM 73234, grey pyroxene andesite. BM 73399 is a more weathered and probably similar rock. See Horsfield, 1816b:133–34.]
52. *Lava from the basin of the river Kali-urang [Kaliurang] near Pagger-pella [Pagerpelah] (vesicular belonging to the lava[s] of later eruptions)*
[Two specimens. BM 73259, grey pyroxene-mica diorite. BM 73287 is weathered grey scoriaceous lava with decomposed phenocrysts. For localities 52–52b, see Horsfield, 1816b:134.]
[Specimen 52b missing]
53. *Compact clay in tables with angles rounded by attrition from the same place*
[Two specimens. BM 73248, dark calcareous quartz-bearing mudstone. BM 73283 is a similar rock. See Horsfield, 1816b:135.]
- 53b. *Stone consisting apparently of petrified wood with sparry depositions*
[Specimen missing. See Horsfield, 1816b:135.]
54. *Compact Pudding-stone (Amygdaloid?) from the same (N° 52)*
[BM 73363, a coarse conglomerate. See Horsfield, 1816b:135.]
[Specimens 55–57 missing]
58. *Basaltes* [sic] *in a state of partial decomposition from the section of an eminence on the road near Kali-lunyar [Kalilunyah]*
[BM 73328, grey pyroxene-bearing tuff. See Horsfield, 1816b:138. Collected October 1814.]
[Specimens 59–62 missing]
63. [There is no entry in the MSS or in the printed catalogue (Horsfield, 1816b:162). The specimen, however, is a red tuff.]
64. [No entry as above (Horsfield, 1816b:162). The specimen is a grey tuff.]
[Specimens 65–68 missing]
69. *Basaltes* [sic] *from the rivulet Kali-Iring [Kali-iring] near the village of Kali-Bebber [Kalibeber]*
[BM 73334, grey pyroxene andesite. Collected October 1814. See Horsfield, 1816b:148.]
[Specimen 70 missing]
71. *Varieties of lava from the foot of the mountain Sundoro [Sundara]—near the village of Kali-Bebber [Kalibeber]*
[BM 73320, black scoriaceous pyroxene andesite. For localities 71–72, see Horsfield, 1816b:149–50. Collected October 1814.]
72. *Varieties of lava from the same place (N° 71) taken on the road between Kali-Bebber [Kalibeber] and Kerteg [Kertek]*
[BM 73268, grey scoriaceous olivine basalt.]
73. *Varieties of lava found on the road between Kerteg [Kertek] and Redsho [Reja]*
[Two specimens. BM 73358, black scoriaceous pyroxene trachyandesite. BM 73297 is reddish weathered lava. See Horsfield, 1816b:151. Collected October 1814.]

74. *Volcanic Tufa between Kali-Bebber [Kalibeber] and Kerteg [Kertek]*
[BM 73305, lithic tuff. See Horsfield, 1816b:151.]
75. *Basaltic-rock separating spontaneously in tables from the tract between Dshittis [Jetis] and Pakkis-wiring [Pakiswiring]*
[BM 73277, grey pyroxene andesite. See Horsfield, 1816b:153.]
76. *Lava from the environs of Mount Sumbing found near Pakkis-wiring [Pakiswiring]*
[BM 73266, a grey vesicular olivine-pyroxene andesite. This is consistent with Neumann van Padang's (1951) data on the G. Sumbing lava.]
[Specimen 77 missing]

The printed catalogue (Horsfield, 1816b:156–63) relating to Horsfield's journey in central Java between 1 August and 4 November 1814 ends with specimen 77. The MS version of the catalogue, with numbers in continuing sequence, relates to specimens that were collected during this and other journeys in Java. Some of Horsfield's collecting localities are marked on Fig. 1.

78. *Tufa—considerably resembling Puzzolana—consist [sic] of basaltes [sic] &c agglutinate by clay—in minute particles—Employed for building and ornaments at Japara*
[BM 54985, grey pyroxene-hornblende andesite.]
79. *Stones of watery deposition enclosing particles of pumice and other volcanic substances similar to the Stone of the same formation found at the side of the hill south of Adshibarang [Adjibarang] (vide above)*
[BM 54985, grey tuffaceous rock. NB The same number as the above but a different specimen.]
80. *Basaltes [sic] in a state of decomposition*
[BM 73174, grey tuff of trachytic composition.]
81. *Bog-Iron-ore*
[BM 73179, ferruginous concretion.]
82. *Red-Iron-Stone*
[Specimen missing]
83. *Irregular concretions of a white Clayey substance—with adhering crystals of sulphur—from the crater of mountain Ungarang [Ungaran]*
[Specimen missing]
84. *Minute Basaltes [sic] from the same (N° 83)*
[BM 73176, grey pyroxene andesite.]
85. *Varieties of lava from the summit of Mount Marapi [Merapi], with other volcanic productions from the same mountain*

[Horsfield visited the region of G. Merapi in 1805 and again in 1810. On one of these (or possibly other) occasions seven specimens were collected. BM 73188, hypersthene andesite. BM 73209, BM 73308 and BM 73310 are augite andesites; BM 73338 is hornblende-pyroxene andesite; BM 73218 and BM 73312 are volcanic sinters.]

86. *Tufa—from the same N° 85*
[Specimen missing]
87. *Lava (?Greenstone) from the southern hills near Menyaran (belonging to the submarine lavas)*
[Two specimens. BM 73270, greenish grey pyroxene andesite. BM 73294 is grey pyroxene-hornblende andesite.]
88. *Tufa from the same*
[Specimen missing]
89. *Minute fragments—chiefly volcanic—from a stratum of Limestone near Menyaran*
[Specimen missing]
90. *Limestone of a gritty texture from the declivities of a slight eminence near Massaran [Masaran]—(near the road, where numerous rocks of the same substance project from the earth)*
[BM 73180, yellow limestone.]
91. *Varieties of Chalcedony from various places in the southern ranges*
[Specimen missing]

92. *Varieties of Agate—from the same (vide N° 91)*
[Specimen missing]
93. *Prase—near Kakkap [Kakap] in the range of southern hills on the road to Padshittan [Pacitan]*
[Two specimens. BM 73345, contact rock with pitchstone and andesite. BM 73272 is a pitchstone.]
94. *Varieties of Hornstone from the environs of Padshittan [Pacitan] and the hills to the eastward of that place*
[Specimen missing]
95. *Jasper from the river [blank] near Padshittan [Pacitan]*
[BM 73166, red jasper.]
96. *Porphyry from various situations in the southern hills in the environs of Padshittan [Pacitan]*
[BM 73286, mottled, red jasper.]
97. *Hornstone porphyry. From the southern hills near Padshittan [Pacitan] and Lorog*
[Specimen missing]
98. *Fragments of petrified wood rounded by attrition found among the pebbles in the river of Padshittan [Pacitan]*
[Specimen missing]
99. *Woodstone from Cheribon [Cirebon]*
[Specimen missing]
100. *Rock of Floetz trap—formation which composes extensive portions of the ridges of the Southern hills passing into Hornstone-porphyry and other stones of the trap family, often covered or pervaded by crystals of quartz*
[Specimen missing]
101. *Flint from the southern hills near Padshittan [Pacitan]*
[Specimen missing]
102. *Limestone in the form of Corallines, found in extensive masses in conjunction with the flint, forming the basis of extensive hills*
[Specimen missing]
103. *Coral-rock filled with depositions or infiltrations of chalcedony, agate &c from the same hills[.]*
see specimen N° 101 and 102
[BM 73317, a replaced rock showing possible original structures. The matrix is composed of quartz, secondary silica, and ferruginous 'cement'.]
104. *Iron-Pyrites found between Padshittan [Pacitan] and Lorog near the village [of] Kerpon [Kerbon]: in the southern hills*
[Two specimens. BM 73329, pyrite cubes and quartz. BM 73362, pyrite cubes aggregated with quartz, sphalerite, etc.]
105. *Iron-Pyrites (place where found not known)*
[Specimen missing]
106. *Bituminous shale-(Brand-schiefer of Kohlen-schiefer Schistus-carbonarius of Blumenb :[])*
found between Padshittan [Pacitan] and Lorog in the same ranges of southern hills (See N° 104)
[BM 73278, contains amber (conceivably retinite) in a shale matrix. Sedimentary rocks of Miocene age are known to occur in this part of Java.]
107. *Yellowish-ochreous clay found in the same stratum with N° 106*
[Specimen missing]
108. *Various stones of aqueous deposition found in the southern hills on the road from Padshittan [Pacitan] to Kerpon [Kerbon] separating into various lamellar or amorphous particles*
[Specimen missing]
109. *Stones of aqueous deposition found chiefly in nodules of a reddish color at various sections of the hills on the road to Kerpon [Kerbon] consisting chiefly of clay*
[Specimen missing]
110. *Stones of Floetz-trap formation resembling Basaltes [sic] found in the sections of the hills on the same route (See N° 109) and between Padshittan [Pacitan] and Lorog, often in extensive beds*

- [BM 73311, highly weathered porphyry.]
111. *Calcareous Spar and Stalactites from the cave of Kalla in the southern hills about [blank] miles west of Padshittan/Pacitan*
[Specimen missing]
 112. *Calcareous rock from various points of the hills of Prowoto [Prawata]*
[BM 73239, pale yellow limestone. Possibly collected by Horsfield as early as 1809. Sedimentary rocks of Pliocene age occur in this area, according to the 1 : 500,000 Geological Map (1977 ed.).]
 113. *Steatite from the hills of Grobogan ?—(it was obtained at Prowoto [Prawata] from Mr S [blank] who brought it from its original situation in the district mentioned.)*
[Specimen missing]
 114. *Clay from the wells near Kuwu—throwing up an earthy substance (Compare the mire-wells described by Pallas and Clarke)⁷*
[Specimen missing]
 115. *Tufa from an extensive layer several miles eastward of Massaran [Masaran]*
[BM 73382, grey pyroclastic rock.]
 116. *Varieties of Limestone from the neighbourhood of Jogorogo [Jagaraga]*
[Specimen missing]
 117. *Amygdaloid from the river at Jogorogo [Jagaraga] taken near the dwelling of the Chinese farmer of Customs*
[BM 73307, fossiliferous limestone containing debris of gastropods, corals, and probably Bryozoa. A Mesozoic or Tertiary limestone.]
 118. *Stone of aqueous deposition taken from the same place (See n° 117)*
[BM 73356, grey clay-siltstone.]
 119. *Amygdaloid resembling lava from the rivulet Kumukus between Jogorogo [Jagaraga]*
[Specimen missing]
 120. *The same substance (see n° 119) taken from another rivulet further eastward on the same route*
[BM 73302, tuffaceous rock.]
 121. *Volcanic stone from the foot of Mount Liman near Ngettos [Ngetos]*
[BM 73252, porphyritic, hornblende-pyroxene andesite.]
 122. *Basalt from the declivities of Mount Liman, near the road between Tunglur and Berbug [Berbeg]*
[Specimen missing]
 123. *Amygdaloid from the same route*
[BM 73344, medium to fine-grained plagioclase- and pyroxene-bearing pyroclastic rock.]
 124. *Amygdaloid taken between Charuban [Caruban] and Tunglur*
[Specimen missing]
 125. *Compact lava from the cave of Selo-mangling [Selamangleng] at the foot of the hill Klottok [Klotok] near Kediri.*
[BM 73255, olivine dolerite.]
 126. *Cavernous lava—similar to n° 12*
[Specimen missing]
 127. *Basalt employed in the construction of the Chunkup at Sentul [BM 73217, pyroxene-bearing trachyandesite.]*
 128. *Lava from the rivulet at Sentul*
[BM 73250, scoriaceous pyroxene andesite.]
 129. *Pebbles out of the basin of the river Konto*
[Three specimens. BM 73162, a hypersthene-augite andesite pebble. BM 73270 is hornblende-pyroxene diorite and BM 73323 is pyroxene andesite.]
 130. *Fragments of the large rocks of Basalt [sic] rising beyond the surface eastwards of the basin of the river Konto*
[Two specimens. BM 73184 and BM 73292 are pyroxene andesites.]
 131. *Tufa from the environs of the village Banaran in the district of Jurung-wangi [Jurungwangi]*
[Specimen missing]

132. *Basalt from the environs of the same village (See n° 131)*
[BM 73280, hornblende-pyroxene andesite.]
133. *White limestone, obtained from the southern districts employed in the construction of various antiquities at the capital of Kediri*
[Specimen missing]
134. *Amygdaloid from Mount Wilis*
[Specimen missing.]
135. *Basalt from Mount Wilis*
[BM 73257, pyroxene andesite.]
136. *Basalt—partially decomposed—from the same (see N° 135)*
[Specimen missing]
137. *Basalt from the declivities of the hill Klottok [Klotok]*
[BM 73243, pyroxene andesite.]
138. *Lava taken from among the pebbles in the River of Kediri near the capital*
[BM 73347, pumice.]
139. *Amygdaloid from the banks of the river of Kediri taken near Waringin-anom from a very extensive layer exposed at the banks of the river*
[Specimen missing]
140. *Lava taken from the basin of the river Pendem on the road between the Capitals of Kediri and Srengat*
[BM 73258, pumice or crystal tuff.]
141. *Basalt from the hill Melliri [Meliri] near Srengat*
[Two specimens. BM 73335, hornblende-pyroxene andesite. BM 73167 is hornblende andesite.]
142. *Amygdaloid from the same (See N° 141)*
[BM 73357, agglomerate.]
143. *Fragments of the stone employed in the construction of the Chandi of Gedog [Gedhog]*
[BM 73229, altered pyroclastic rock. The specimen is clearly carved on one surface and, as the catalogue claims, is from a temple.]
144. *Fragments of the stone employed in the construction of the buildings of Penataran*
[BM 73301, pyroxene andesite.]
145. *Volcanic pebbles found near the village Benchi [Benci]—between Legok and Gebuganging [Gebug-angin]*
[Specimen missing]
146. *Volcanic pebbles out of the Basin of the River Si-walan [Siwalan] near the road leading from Blitar to Gebuganging [Gebug-angin]*
[BM 73289, dark pyroxene-bearing andesite.]
147. *Volcanic fragments from the Basin of the river Bajang—on the same road (See N° 146)*
[Specimen missing]
148. *Fragments of various antiquities found near the village Plumbangan in the district of Gebuganging [Gebug-angin] shewing the constitution of the Basalt in this tract*
[BM 73196, grey pyroxene-hornblende andesite.]
149. *Pebbles from the Basin of the river Semut flowing from the mountain Klut [Kelut]—eastwards of Gebug-angin [Gebug-angin]*
[Two specimens. BM 73205, grey hypersthene-augite andesite. BM 73203 is grey scoriaceous lava.]
150. *Pebbles from the basin of the river Lesso [Leksa], a large stream arising from the foot of Mount Kawi [Kawi]*
[Two specimens. BM 73190, pale grey pyroclastic rock or sandstone. BM 73177 is grey hypersthene-augite-biotite andesite.]
151. *Specimens of Trap rocks from the summit of Mt Klut [Kelut]*
[Four specimens. BM 73327, hypersthene-augite-hornblende andesite. BM 73228 is hypersthene-pyroxene-hornblende andesite; BM 73192 and BM 73208 are hornblende-two pyroxene andesites.]

152. *Amygdaloid from the summit of Mount Klut* [Kelut]
[Two specimens. BM 73263, hornblende-two pyroxene andesite. BM 73349 is greyish red two pyroxene andesite.]
153. *Varieties of Trap-rock taken from various points in the Basin of the River Siwalan flowing from the summit of the Klut* [Kelut]
[Twelve specimens. BM 73199, hypersthene-augite-hornblende andesite; BM 73380, medium grained hornblende diorite; BM 73359, hornblende-two pyroxene andesite; BM 73370, two pyroxene andesite; BM 73391, hornblende-biotite hornfels; BM 73260, hypersthene andesite; BM 73295, altered hornblende andesite; BM 73186, altered pyroxene-bearing lava; BM 73250, hypersthene-augite andesite; BM 73216, pyroxene andesite; BM 73304, two pyroxene-hornblende andesite, and BM 73211 is pyroxene-hornblende granulite.]
154. *Calcined Trap of a white color thrown from the Crater of Mountain Klut* [Kelut]
[Two specimens. BM 73220, quartzite. BM 73251 is pumice.]
155. *Lava from the basin of the river Siwalan*
[BM 73233, dark pyroxene andesite.]
- 155b. *Ball of Lava, probably artificial from the vicinity of the capital of Blitar*
[Specimen missing]
156. *Calcined Trap—resembling pumice, taken out of the strata composing the banks of the river Si-Walan* [Siwalan]
[Specimen missing]
157. *Fragments resembling sandstone and amygdaloid taken from the basin of the same river (See n° 156)*
[Specimen missing]
158. *Semi-decomposed amygdaloid taken from an earthy stratum at the banks of the same river (n° 156)*
[Specimen missing]
159. *Trap-rock taken from the village Semen, at the eastern boundary of Srengat near the foot of Mount Kawy* [Kawi]
[BM 73375, grey pyroxene andesite.]
160. *Trap-rock from the river Soso near the northern boundary of Srengat*
[BM 73226, weathered medium-grained lava.]
161. *Specimens of pebbles and fragments of Trap-rock from the eastern branch of the river of Kediri near the hanging bridge on the route to Selo-gurit* [Selagurit]
[Specimen missing]
162. *Impure limestone from the hill Pandan* [Pandhan]—connected to the low ridge South of the river last mentioned (N° 161) taken between Besole and Kudung-bunder [Kedhungbunder]
[BM 73353, creamy-pink mottled limestone.]
163. *Stones formed by Deposition from water taken from the low southern ridge on the road from Klampok to Ngekkul* [Ngekkul] two villages of the district of Ludoyo [Lodaya]
[BM 73397, pale flaggy siltstone.]
164. *Sandstone from the same road (See n° 163)*
[Specimen missing]
165. *Sandstone employed as a whetstone from Gogo-Dessa* [Gogo-Desa] in the district of Ludoyo [Lodaya] westward of Ngekkul [Ngekkul]
[BM 73400, buff silty sandstone.]
166. *Fragments of Amygdaloid composing the rock at the Cave near the summit of the hill Peggat* [Pegat]
[Specimen missing]
167. *Volcanic pebbles strewed on the surface of the hill Gadjakombang one of the points constituting the summit of the Mountain Klut* [Kelut]
[BM 73422, grey hornblende-pyroxene andesite.]
168. *Charcoal taken from the Alluvial Strata in the valley of Jurung-Gandul* [Juranggandhul] on the lower declivities of the mountain Klut [Kelut]
[Specimen missing]

169. *Lava from the Basin of the river Gedog* [Gedhog]
[BM 73404, grey scoriaceous pyroxene andesite.]
170. *Fragments from the strata composing the sides of the basin of the river Gedog* [Gedhog]
[Specimen missing]
171. *Trap-rock taken from its original situation in the ravine east of the valley of Gedog* [Gedhog]
on the road to the Crater
[Two specimens. BM 73200, pyroxene andesite. BM 73395 is basalt.]
172. *Various fragments of Trap found in the Basin of the same river (See n° 171) between the village Rawa and the external walls of the Crater*
[Two specimens. BM 73306, quartz-tourmaline rock. BM 73384 is medium-grained augite andesite.]
173. *White gritty deposition found in extensive layers between the alluvial strata on the banks of the river Rowo* [Rawa]
[Specimen missing]
174. *Limestone from Gamping taken near the source of the large river of Rowo* [Rawa] *from the hills bounding the Rawa or lake which covers this tract, in the south*
[BM 73198, buff to pink limestone.]
175. *Trap from a steep pile composing the hill Budeg near the Guwo* [Guwa] *or Cavern*
[BM 73394, andesitic tuff.]
176. *Trap-rock passing into Amygdaloid—from the hill Rajeg-wessi* [Rajegwesi]
[Specimen missing]
177. *Lime-stone projecting in large rocks from an eminence on the eastern banks of the river of Kampak near the village of Bendo* [Bendha]
[BM 73421, buff fossiliferous limestone bearing Miocene crustacean remains.]
178. *Amygdaloid rock passing into limestone from the road towards Rit a precipitous valley between Kampak and Segoro-weddi* [Segara Wedhi]
[Specimen missing]
179. *Limestone taken from the same valley (N° 178) from an adjoining rock*
[BM 73381, buff fossiliferous limestone.]
180. *Various fragments of Trap-rock from the piles in the same valley near Rit (See n° 178)*
[BM 73378, dark fossiliferous limestone.]
181. *Decomposed Trap-rock from the hill between Kampak and Segoro-weddi* [Segara Wedhi]
[Specimen missing]
182. *Fragments of Trap-rock taken from the southern declivity of the hill between Kampak and Segoro-weddi* [Segara Wedhi]
[BM 73348, welded tuff.]
183. *Pebbles from the shore at Segoro-weddi* [Segara Wedhi]
[Specimen missing]
184. *Pebbles out of the bed of the River of Segoro-weddi* [Segara Wedhi] *taken near the village of Prigi*
[Specimen missing]
185. *Fragments of Hornstone, Hornstone Porphyry &c found in various points detached on the surface near the village Bendo* [Bendha] *in the district of Kampak*
[BM 73396, drusy quartz rock.]
186. *Pebbles taken at different points from the bed of the river of Kampak*
[BM 73327, jasper-bearing conglomerate.]
187. *Trap-rock from the ranges north of the capital of Trengale* [Trenggalek]
[Two specimens. BM 73178, porphyritic andesite. BM 73432 is porphyritic trachy-andesite.]
188. *Fragments from a steep pile of calcareous rock called Watu-lawan* [Watulawang], *between Trengale* [Tranggalek] *and Sawu*
[BM 73202, buff limestone probably of Miocene age.]
189. *Stone formed by aqueous deposition taken near the same rock (See N° 188)*
[Specimen missing]
190. *Stone of watery deposition taken from the hill Bubug on the further track towards Sawu*

- [Specimen missing]
191. *Amygdaloid taken from the same track (See N° 190)*
[BM 73411, porphyritic pyroxene andesite.]
192. *Limestone, from the same track*
[Specimen missing]
193. *Trap-rock from the summit of the hill Iju [Ijo] forming one of the principal points of the ranges south of Sawu*
[Specimen missing]
194. *Stones of deposition, taken in the ascent of the same hill*
[BM 73401, quartz tuff.]
195. *Amygdaloid forming part of a huge pile, conspicuous from the village Sawu in the ranges situated nearly directly south of that village*
[BM 73195, pyroxene andesite.]
196. *Fragments of Hornstone dispersed on the surface at the village Maran [Maron] near Sawu*
[Specimen missing]
197. *Detached fragments of carnelian found on the surface near the pile of Amygdaloid (See n° 195)*
[BM 73374, is better described as chalcedony.]
198. *Various specimens of lithology from the environs of the village Sawu*
[BM 73197, porphyritic trachyandesite.]
199. *Hornstone porphyry from the hill Chumbri [Cumbri]*
[Two specimens. BM 73426, jasper. BM 73230 is a ferruginous drusy quartz rock.]
200. *Splintery Hornstone from Chumbri [Cumbri]*
[BM 73189, tuff cut by a fine quartz vein.]
201. *Varieties of Sandstone and Amygdaloid, taken in conjunction with N° 199 and 200 from the hill Chumbri [Cumbri]*
[Two specimens. BM 73339, silicified porphyritic lava. BM 73419 is silicified lava.]
202. *Limestone taken from the hill Chumbri [Cumbri] above the tract covered with Hornstone*
[Specimen missing]
203. *Incrustation covering the Hornstone Porphyry in the rivulet at the foot of the hill Chumbri [Cumbri]*
[BM 73429, porphyritic andesite covered with an envelope of calcareous algal (?) growth.]
204. *Various objects of lithology from Chumbri [Cumbri]*
[Specimen missing]
205. *Pebbles out of the western branch of the Bengawan (or large river of) Pronorogo [Panaraga] from the village Blemben [Blembeng] on the road to Kunti [Kunthi]*
[Three specimens. BM 73265, andesite. BM 73373 is banded and contorted rhyolite (?), and BM 73371 is amygdaloidal lava.]
206. *Varieties of objects of Lithology from the hill Ngebel*
[Specimen missing]
207. *Various Specimens from the mountain Lawu*
[BM 73418, pyroxene andesite.]
208. *Rock of Floetz-trap formation forming the hill Chongol [Congol] in the ranges south of Suro-kerto [Surakarta] near Kedung-prow [Kedhung-prau]*
[Specimen missing]
209. *Alluvial-rock and sandstone of a close texture from the same ranges See n° 208—taken from the hills in a southern and in a western direction from Kedung-prow [Kedhung-prau]*
[BM 73419, pyroxene andesite.]
210. *Limestone employed in burning quicklime at Suruwan [Suruhan]*
[BM 73352, white porous limestone.]
211. *White sandstone, cut into Slabs, tabulae &c employed at the capitals for flooring houses*
[BM 54985, white microfossiliferous limestone.]
212. *Limestone from the environs of the village of Karung-Joho [Karangjaha], taken in conjunction with the Sandstone (n° 211)*
[BM 73402, porous limestone.]

213. *Amygdaloid (or puddingstone) taken from the southern ranges near Karang-Joho [Karang-jaha], above the Sandstone*
[BM 73416, weathered lapilli tuff.]
214. *Specimens from the hill Wejel [Wijil] between the Bazar Tanjung and Pependan, on the route to Kedung-prow [Kedhung-prau]*
[Specimen missing]
215. *Fragments of the hills between Pepedan and Suruwan [Suruhan]*
[Specimen missing]
216. *Various specimens taken at a cavern in the northern declivities of the hill Chongol [Congol] (near Kedung-Prow) [Kedhung-prau] from a steep pile of Trap*
[Specimen missing]
217. *Fragments of the wall of Mattaram [Mataram]—consisting of Basaltic Trap in a semi decomposed state of a white color*
[BM 73431, pumice tuff.]
218. *Specimens of Tufa (padas) from the bed of the river Ello [Elo] at the bridge between Bojong and Magelan [Magelang]*
[Specimen missing]
219. *Specimens from the bed of Progo [Praga] river*
[Two specimens. BM 73187, pyroxene andesite. BM 73420 is weathered lava.]
220. *Specimens from the southern range about 2 miles west of Boro-budur [Barabadur]*
[Two specimens. BM 73379, hornblende andesite. BM 73169 is weathered lava.]
221. *Specimens of the temple of Borobudur [Barabadur] exhibiting several of the varieties of Stone of which it is constructed (all belonging to the trap family)*
[Three specimens. BM 73219 and BM 73385 are pyroxene andesites. BM 73415 is a pyroxene-hornblende andesite.]
222. *Pebbles from the Rivulet Kaliurang arising from the Sundoro [Sundara] with breccia and lava taken from the basin of the same river*
[Two specimens. BM 73386, hypersthene-hornblende andesite. BM 73238 is a weathered conglomerate.]
223. *Lava taken from the Strata of accumulation in the ravine at the foot of the Sundoro [Sundara] which transmits the river Progo [Praga]*
[Two specimens. BM 73383 and BM 73269 are pyroxene andesites.]
224. *Lava in a state of decomposition from a section of a hill on the route from Chempoko [Cempaka] to Blederan*
[Specimen missing]
225. *Compact Trap (or Greenstone) separating conchoidal like Hornblende, taken from a hill on the same route*
[BM 73410, hypersthene andesite.]
226. *Earthy deposition mixt with Sulphur from the Crater of Diyeng [Diëng]*
[Specimen missing]
227. *Varieties of calcined Basalt nodular. lamellar &c from the same*
[Two specimens. BM 73430, buff limestone. BM 73423 is pyroxene andesite, with a whitened and weathered 'crust'.]
228. *Simple earthy deposition white & clayey, from the same*
[Specimen missing]
229. *The same, consisting of calcined basalt formed into a clayey mass, from the Crater of Koppo [Kopo]*
[Specimen missing].
230. *Fragments of the entire masses of Trap in the Crater of Koppo [Kopo], calcined only on the external surface*
[BM 73365, olivine-pyroxene basalt with a weathered 'crust'.]
231. *Scoreaceous [sic] substance found on the same plain, ([N°] 230) mixt with calcined basalt and Clay, impregnated with particles of Sulphur*
[BM 73409, scoriaceous lava and lappili tuff.]

232. *Semi calcined Basalt of a reddish color from Koppo* [Kopo]
[BM 73298, red/purple lava with phenocrysts and a white weathered 'crust'.]
233. *Red lava (See the Specimens) from the Crater of Koppo* [Kopo]—NB this occurs frequently in various parts of the summit of the mountain Prow [Prau] or Diyeng [Diëng]
[Specimen missing]
234. *Varieties of calcined Basalt (and trap) from the Crater of Koppo* [Kopo]
[Three specimens. BM 73163, weathered lava with a whitened 'crust'. BM 73424 and BM 73425 are pumice.]
235. *Varieties of the white clayey deposition (from the particles of calcined basalt) impregnated with Sulphur, dispersed or accumulated in various parts of the plain of Koppo* [Kopo]
[Specimen missing]
236. *Detached fragments of Trap from the river Krecek* [Krecek], flowing into the lake of Menjer [Menyir]
[Two specimens. BM 73271, pyroxene andesite. BM 73182 is olivine basalt.]
237. *Pebbles from the river Serayu, near Blederan*
[BM 73413, biotite microdiorite. See specimens localities 69–76.]
238. *Semi decomposed breccia resembling tufa, from the road between Blederan and Kerteg*
[BM 73213, agglomerate.]
239. *Fragments of lava, taken from the strata of accumulation, on the same route (as n° 238) between Bo-merto* [Bomerta] *and Kerteg*
[BM 73390, scoriaceous pyroxene andesite.]
240. *Specimens of the varieties of Basalt found in the route from Kerteg to the valley of* [the] *Begalo* [Begaluh] *river*
[Two specimens. BM 73372, hornblende-pyroxene andesite. BM 73388 is pyroxene andesite.]
241. *Pebbles from the River Begalo* [Begaluh] *on the road between Kerteg and Kali-lusi* [Kali Lusi]
[Two specimens. BM 73212 and BM 73221 are pyroxene andesite.]
242. *Two fragments of trap taken from the river Wang* [Wangi ?], *between Kali-lusi* [Kali Lusi] *and Luwano* [Loano]
[Only one specimen survives. BM 73275 is hornblende-pyroxene andesite.]
243. *Semi-decomposed Breccia from the descent between Luwano* [Loano] *and Brengkelan, forming extensive strate* [sic] *near the valley of the Bogowonto* [Bagawanta], *on which are dispersed separate fragments of Basalt*
[Specimen missing]
244. *Sandstone, compact, from the same route*—NB this is also found in regular tables or Slabs
[BM 73222, yellow gritty limestone.]
245. *Pebbles from the Bogowonto* [Bagawanta] *at the ford, on the high road from Jokjokerto* [Jogjakarta] *to Brengkelan*
[Three specimens. BM 73273, BM 73293 and BM 73299 are hornblende-pyroxene andesites.]
246. *Calcareous rock from the first ascent near Pliper* [Plipir] *on the road from Brenkelan to Jokjokerto* [Jogjakarta]
[BM 73242, white limestone. Miocene rocks are mapped as occurring in this area.]
247. *Calcareous rock, cellular and stalactitic from the cave Se-Bendo* [Sibendah?] *near the village Se Bollong* [Sibolong] *on the same route (See n° 246)*
[BM 73406, yellow concretionary limestone.]
248. *Fragments of a horizontal stratum pervading a large mass of rude Breccia exposed in the same route. (See N° 246)*
[BM 73170, weathered igneous rock.]
249. *Various fragments taken near the summit of the ridge on the same route (See n° 246.)*
[BM 73398, weathered igneous rock.]
250. *Diversified fragments from the pile of trap at Kali-tenga* [Kalitengah], *on the route from Brengkelan to Luwano* [Loano]
[Two specimens. BM 73201, weathered igneous rock. BM 73244 is altered olivine-pyroxene andesite.]

251. *Trappean pebbles from the bed of the river Gessing [Gesing] taken at the village of the same name*
[BM 73364, grey chlorite-bearing andesite.]
252. *Calcareous pebbles from the same ([N°] 251)*
[73254, limestone pebble.]
- 253[a] *Fragments from an immense layer of trap passing the bed of the river Gissing [Gesing] at the village of the same name*
[Specimen missing]
- 253b. *Fragments of aqueous deposition taken at the termination of the transverse ranges between Bogowonto [Bagawanta] and Progo [Praga] near the village Griga*
[Two specimens. BM 73214, olivine-pyroxene basalt. BM 73206 is slightly weathered chlorite and calcite-bearing andesite.]
254. *Fragments of decomposed Breccia resembling Tufa (See N° 238) forming deep perpendicular strata at the banks of the river Progo [Praga] at Grubu [Grugu ?]*
[Specimen missing]
255. *The Same (N° 254) consisting of coarse fragments strewed near the banks of the same river*
[BM 73408, lapilli tuff.]
256. *Pebbles out of the river Progo [Praga] at Grubu [Grugu ?] (See N° 254 & 255)*
[Two specimens. BM 73246, a calcareous (?) tuff. BM 73331 is limestone.]
257. *Limestone from the foot of the hill on the road to the cave Siro-Chollo [Siracala] near Krettek [Kretek]*
[BM 73210, white crystalline limestone.]
258. *Limestone from the same road taken at the acclivity about halfway to the cave*
[BM 73236, limestone matrix with well developed calcite crystals.]
259. *A fragments [sic] of the trap rocks dispersed on this limestone ([N°] 258)*
[BM 73377, basalt.]
260. *Fragments of the limestone forming steep perpendicular piles on the summit of the ridge containing the cave Siro-Chollo [Siracala]; naked and distinctly visible at a considerable distance*
[BM 73354, yellow crystalline limestone.]
261. *Fragment of limestone taken at the cave of Siro-Chello [Siracala]*
[BM 73235, yellow crystalline limestones.]
262. *Fragments of the white stone or decomposed Breccia (resembling that of Mattaram) [Mattaram] employed in building the walls of the cave just mentioned ([N°] 261)*
[BM 73237, wedled tuff.]
263. *Fragments of trap employed in constructing the steps leading to the cave—([N°] 261)*
[BM 73326, dark pyroxene andesite.]
264. *Fragments of a large, steep pile of trap rocks terminating at the ocean near Manchingan [Mancingan], within 200 yards of the warm bath Terang-wedang [Parangwedang?]*
[Two specimens. BM 73403 and BM 73281 are pyroxene andesites.]
265. *Fragments of the same ([N°] 264) pervaded by extensive veins of calcareous spar—NB The trap is in some parts of this pile firm and entire in others loose, ochreous & decomposed*
[Two specimens. BM 73321, vein of brown calcite in a limestone. BM 73433 is a vein of calcite in a weathered igneous rock.]
266. *A fragments [sic] of pumice found near the same pile [Specimen missing]*
267. *Fragments of the steep amygdaloidal pile terminating one of the ranges at the foot of which the warm bath is situated*
[BM 73414, agglomerate.]
268. *Fragments of several separate rocks near the same pile (N° 267) pervaded with veins of Calcareous spar*
[BM 73343, agglomerate cemented and veined by calcite.]
269. *Limestone from the rock projecting at Parang-tritis [Parangtritis]*
[BM 73241, yellow fossiliferous limestone.]
270. *Fragments of the Stalactites formed at Parang-tritis [Parangtritis]*
[BM 73428, crystalline limestone with rings of deposition.]

271. *Limestone from the point Selo-Sumbur [Selasumber], east of Parang-tritis [Parangtritis] terminating the long bay that is here found in the coast*
[Specimen missing]
272. *Fragments of an immense pile of trap-rock terminating one of the ranges between Krettek [Kretek] and Manchingan [Mancingan]*
[Two specimens. BM 73366 and BM 73368 are hornblende-pyroxene andesites.]
273. *Tufa partially decomposed, employed in constructing a well at Brambanan [Prambanan]. NB This well is situated near the celebrated antiquities, and a work of the ancient inhabitants or Bramins*
[BM 73355, welded tuff.]

The whereabouts of specimens 274–366 referred to in the MS catalogue in the India Office Library and Records, London (MSS. Eur. F. 53) is unknown. Considerations of space also make publication of their descriptions impossible.

Horsfield's geochemical analyses

In addition to his prodigious field collecting activities in Java Horsfield was also busy in the laboratory. His chemical analyses of volcanic ash thrown out by G. Guntur in 1803 and pyrite ore found in the highlands of Jakarta were published in 1814 (Horsfield, 1814a) and surprisingly reveal him to be a competent analyst by the standards of his day. These analyses, however, should first be set within the context of the mineralogical/petrological chemistry of the time. Hey (1973) points out that T. O. Bergman (1735–1784) was probably the first to attempt a complete analysis of a mineral in the 1770s. M. H. Klaproth (1743–1817) added his own contribution to analysis during the late eighteenth century, and by 1784 Richard Kirwan (1733–1812) was able to list 74 analyses of rocks and minerals which had been done by himself and others. The work of Kirwan (1784) and Klaproth (1801) was probably known to Horsfield, whose analyses, though published in 1814, were recorded in the Dutch language in 1803. A translation of Horsfield's (1814a) analysis scheme, annotated with chemical notes, is given below.

Chemical analysis of a volcanic sand and an iron-ore

By Thomas Horsfield, Med. Dr.

(*Verh. Batav. Genoot. Kunst. Wet.*, 7, no. III (1814), pp. 1–8.)

I. Chemical analysis of a volcanic sand

In the night of 6 and 7 April 1803, and during a few hours of the last mentioned day a fine, black, sandy material was precipitated very slowly from the air in the town and neighbourhood of Batavia. Initially it was not known where this material came from, and opinions about it were divided. After a few days intelligence was obtained from the highlands that Thunder Mountain (*Donderberg*), or Goenoeng Goentoer, in the district of Timbangantang, had been burning violently from the 3rd to the 15th of April, and had thrown out very great quantities of Lava [*Lava*] and Sand [*Zand*]; the finest particles of this sand had been carried by the southerly wind as far as Batavia.

The purpose of the following experiments was to determine how far this sand in constituent-parts corresponded with the usual Volcanic emission, and it appeared from this, that this same [sand] is only a powdered Lava. The colour of this Volcanic Sand is black or very dark greyish, and when collected in some quantity resembles a very fine powder, in which a few glistening particles can be observed; this same material is strongly attracted by the Magnet.

Experiment I. Two hundred grains [in weight] of this Sand were heated for an hour in an ounce of Aqua regia [*Koningswater*] which had been diluted with a few ounces of distilled water; the liquid was now isolated by filtration, and the residue, having been washed out with distilled water, was carefully dried; it weighed exactly *one hundred and seventy five* grains.



Plate 4 Gunung Guntur photographed in 1978. This mountain was the source of the ash which Horsfield attempted to analyse in 1803.
Reproduced by permission of Mr N. Rock.

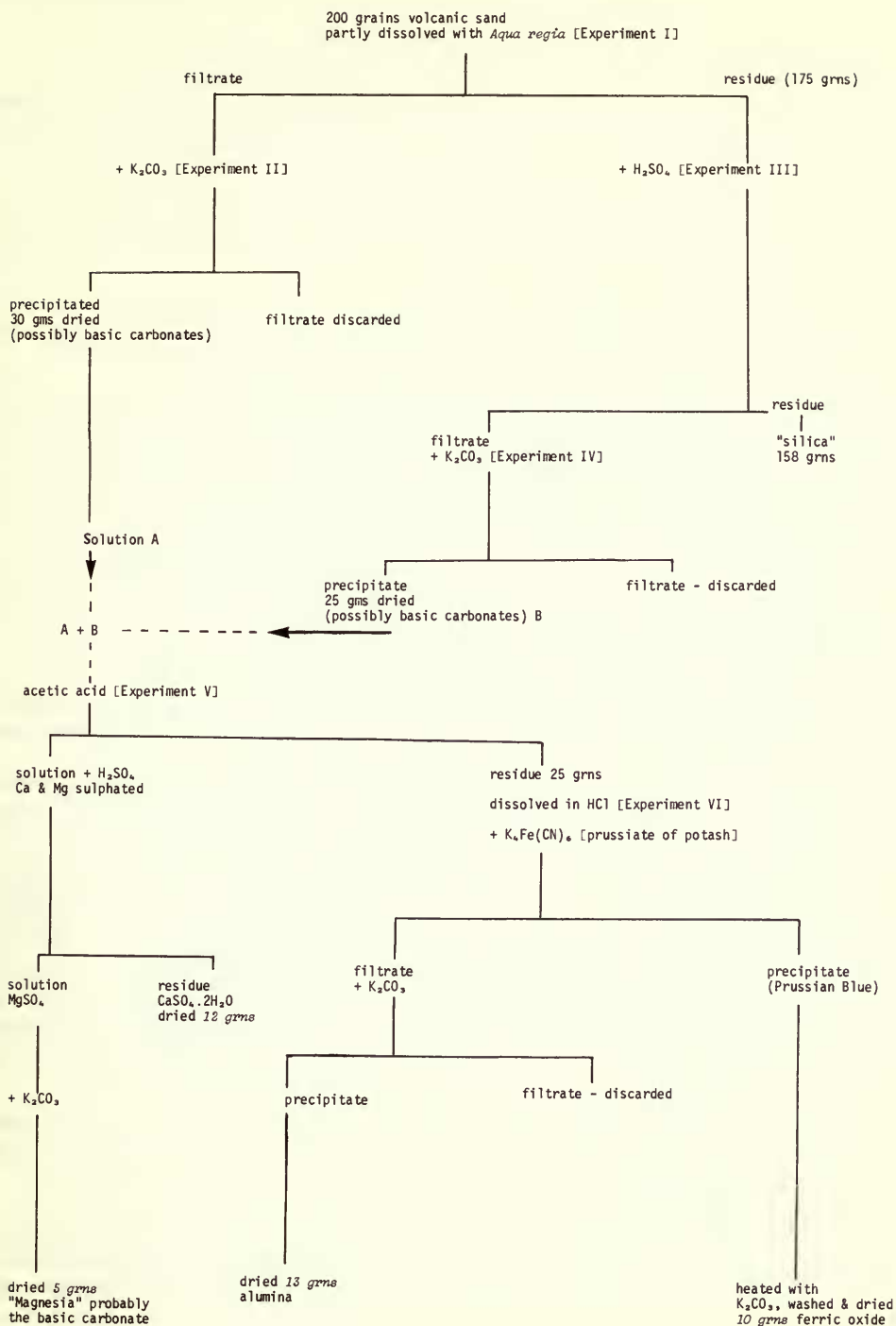


Fig. 2 A flow diagram illustrating Horsfield's analytical scheme for volcanic ash. By this scheme any manganese present would be found with the magnesia, titania and phosphate with the alumina, and the alkalis would be lost.

Experiment II. From the solution the dissolved parts were precipitated by the plant alkali [*planten loog-zout*], which on the filter [*filtrum*] well washed out and carefully dried, weighed *thirty grains*.

Experiment III. Since the remaining Sand from the First Experiment was still partly attracted by the Magnet, so was the same [sand] diluted with sulphuric acid [*zwavel-zuur*], repeatedly heated, until no soluble parts showed; the insoluble residue, after washing out, was collected on the filter and dried; it weighed *a hundred and fifty eight grains*; nothing of this was attracted by the Magnet.

[The material undissolved by the aqua regia followed by sulphuric acid will not be all silica; whether the 'sand' was volcanic glass or partly crystalline it will not wholly be decomposed by acid.]

Experiment IV. To this solution made by sulphuric acid [*zwavel-zuur*] was added the plant alkali [*planten loogzout*], until no further precipitation took place—The dried residue weighed *twenty five grains*.

Experiment V. The residue of the last Experiment, weighing twenty five grains, and that of the second Experiment, weighing thirty grains, were mixed and heated with distilled acetic acid [*azijn*], in order to determine the lime [*kalk*] or magnesia [*bitteraarde*], which they might contain.—The indissoluble parts were washed out on the filter, and then carefully dried; they weighed exactly *twenty five grains*.—The acetic acid [*azijn*] was evaporated until dry, and on the residue cast diluted sulphuric acid [*zwavel-zuur*], in order to combine the calcareous earth [*kalkaarde*] to the selenite [*seleniet* or *sulphas calcis*] and with the magnesia [*bitteraarde*] to epsom salt [*bitterzout* or *sulphas magnesia*]. A few ounces of the distilled water were added to this, in order to separate the epsom salt [*bitterzout*] from the indissoluble selenite [*seleniet*].

From the filtered liquid the magnesia [*Bitteraarde*] was precipitated by the plant alkali [*planten loogzout*], which when dried weighed *five grains*.

The dried selenite [*Seleniet*] weighed *eighteen grains*; (of which about two-thirds or twelve grains were calcareous earth [*kalkaarde*], the remainder were sulphuric acid [*zwavel-zuur*] and water).

[The united potassium carbonate precipitates, treated with acetic acid, will extract nearly all the lime and magnesia, but some alumina may be dissolved as well, and if so will be counted as magnesia; the small quantity of magnesia found suggests that this separation was in fact good. 'Selenite' formation will not give a perfect separation of lime from magnesia as gypsum is not quite insoluble (solubility about 0.5%), but again, the magnesia suggests quite a good separation. The 'magnesia' will be basic magnesium carbonate before drying; what remains after drying depends on the drying temperature, but Horsfield's 2.5% MgO is not far out—although the 'silica' will include much MgO, probably as pyroxene (insoluble in acid). The dried 'selenite' is a problem; gypsum is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ with 32½% (not two-thirds) CaO; if dried at a temperature above 120°C, it loses water leaving $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ (Plaster of Paris), which has 39% CaO; so the selenite contained somewhere between 6 and 7 grains CaO.]

Experiment VI. The remaining precipitate after treatment with acetic acid [*azijn zuur*], which weighed twenty five grains (see last experiment) was dissolved in diluted muriatic acid [*zeezout zuur*]: To the solution was added Prussiate of potash [*blaauwzuur loog zout* or *Prussias potassae*], for as long as any precipitation took place.

The Prussian blue [*blaauw-zure ijzer* or *Berlijnsch blaauw*] was collected on a filter cloth, heated with plant alkali [*planten loogzout*], and well washed out with distilled water; by that means the Prussic acid [*blaauw zuur*] was broken up and only the iron left, which dried weighed *ten grains*.

Experiment VII. To the filtered liquid, after the removal of the Prussian blue [*blaauw zure ijzer*], was added plant alkali [*planten loogzout*] until no further precipitation took place.—The precipitate was then well washed out and dried, it was pure alum earth [*Aluin-aarde*], and weighed *thirteen grains*—

[The precipitate would not lose all water on drying, it takes a bright red heat to dehydrate alumina fully—but there were probably not less than 12 grns Al_2O_3 .]

Two hundred grains of this volcanic Sand thus consist of:

5 grains of magnesia [<i>Bitteraarde</i>], Experiment V.	[2·5% magnesia]
12 grains of calcareous earth [<i>Kalkaarde</i>], Experiment V.	[6% lime]
10 grains of iron [<i>Yzer</i>], Experiment VI.	[5% total iron oxides]
13 grains of alum earth [<i>Aluinaarde</i>], Experiment VII.	[6·5% alumina]
158 grains of silica (siliceous earth) [<i>Kiezelaarde</i>], Experiment III.	[79% silica (see note to Experiment III)]
198 grains	
2 lost	[10% alkali's lost?]

200

According to the exact chemical analysis the usual volcanic products like Lava [*Lava*], Basalt [*Basalt*] &c. consist of silica [*Kiesel*], alum [*Aluin*] and calcareous earth [*Kalkaarde*] with a little magnesia [*Magnesia*] and iron [*Yzer*], in different proportion of mixing; to show [prove] the similarity of the constituent-parts of this sand with these volcanic substances was the purpose of the narrated experiments.

[G. Guntur is known to produce basalts and augite-hypersthene andesites. Neumann van Padang (1951:91) gives two analyses of the lava. A value of 55–65% for the silica might reasonably be expected for andesite (Le Maitre 1976), and for pyroxene andesites in general (Moore *et al.* 1979 Nos 73, 104, 117, 120, etc), so Horsfield's silica figure of 79% is very high for an andesite. Neither aqua regia nor dilute sulphuric acid however is competent to give a complete attack on the silicates. The roughly equal proportions (but not the values) of CaO , Al_2O_3 , and total iron, and about half as much MgO in the final analysis, look reasonable. For this date, however, this is a good analysis. The factor of two-thirds for the lime in 'selenite' was current in Horsfield's day and was not corrected generally until about 1807–10. Klaproth used a better figure, but most of his work, which included the first really effective attack on the silicates (fusion with alkali), was produced around 1803–07 and would not have been available to Horsfield. See also note to Experiment V above. (We are grateful to Dr M. H. Hey of the Department of Mineralogy, British Museum (Natural History) for this and the other notes on Horsfield's analysis schemes which are inset with the translation, with the exception of the note on Junghuhn.)

The very different results of the chemical analysis made by P. J. Maier in Batavia in 1843 of the volcanic ash thrown out by G. Guntur on 4 January of that year was largely attributed by J. C. A. Diederichs (under whose supervision the experiments were conducted) to the advance in chemical analysis since Horsfield's day. Maier's analysis showed a marked *decrease* in the percentage of silica (34·2%) and magnesia (0·68%), and a substantial *increase* in iron-oxide (18·1%). Junghuhn, who fully records the details of Maier's analysis and Diederichs' comments, defends Horsfield's analysis by rightly emphasizing the fact that the same volcano will throw out different products during different eruptions (Junghuhn, 1853–54, II:115–18).

Assuming that the chemical analyses concerned are accurate (for discussion see Hey, 1973), the present day petrologist uses the variation of chemical composition in lavas to establish a differentiation trend which can be represented graphically. The history of the evolution of petrological theory however is too involved to discuss here, but an early and still valuable landmark was written by A. Harker in 1909, *The natural history of igneous rocks*. Methuen, London. 384 pp.]

II. Chemical experiments with Massoerong

The mineral substance, which is the subject of the following experiments, is an iron-ore, which is found in the Jakarta Highlands: the pieces are of different size, of half a drachma to some pounds in weight; the outside colour is whitish-yellow, and glittering; they are brittle and easy to shatter,

on the inside they are lighter in colour and more glittering. Most of the fragments are of an irregular crystal shape; some have the shape of regular four-sided, sharp edged crystals; by the Natives they are often made into knotty points [knobs: *knoopen*]; The usual Dutch name is steel-stone [*staal-steen*].

The following experiments show the constituent-parts.

Experiment I. A hundred grains [in weight] of this powdered iron ore in a small covered crucible were exposed to a fierce heat for half an hour; when the crucible was opened the mass blazed like pyrophorous [*pijrophorus*] and abundant sulphurous fumes [*zwavel dampen*] arose; there were no traces of Arsenic [*Arsenic*]. After cooling, the mass weighed *seventy five* grains—It was now a dark brown colour, and was easy to grind to powder.

[The 'pyrophorous' was simply finely divided metal, usually iron; if exposed to air while still hot, it oxidises so rapidly that a sample that has cooled a little below red heat will glow brightly again,—hence the name.]

Experiment II. A hundred grains of finely powdered Massoerong were heated with an ounce of dilute muriatic acid [*zee-zout zuur*]; during the heating many sulphurous fumes [*zwavel dampen*] developed.—The liquid was separated and the residue well washed out; it weighed dried *ninet* grains, and it was still strongly attracted by the Magnet.

[An attack with dilute hydrochloric acid (muriatic acid) will not dissolve pyrite, and only attacks magnetite slowly. It would dissolve pyrrhotine and would attack any partly oxidised pyrite. From this experiment it appears that the ore probably contained about 90% of pyrite + magnetite, or more probably the magnetic mineral pyrrhotine, + gangue.]

Experiment III. This residue was mixed in a small crucible with 15 grains of coal dust and made red-hot for an hour; the residue now repeatedly heated with diluted sulphuric acid [*zwavel zuur*] until nothing more was dissolved; on the liquid swam glassy little scales, which on the fire smoked like sulphur [*zwavel*]. After the decomposition the residue weighed *twelve* grains, and was not attracted by the Magnet; it was for the greater part Silica [*Kiezel-aarde*].

[This experiment determines the gangue at 12%; the ignition with coal dust would reduce the pyrite, magnesite, and pyrrhotine to acid-soluble metal.]

Experiment IV. The solutions of the Second and Third Experiments were mixed, and by the plant alkali [*planten loog-zout*] all the dissolved parts precipitated, which on the filter cloth were washed out and after this dried.—They weighed *seventy* grains.

[This experiment found ferric oxide 70%, corresponding to 49% iron; this figure is probably a little high, for if the dried (not ignited) iron oxide was substantially $\text{FeO} \cdot \text{OH}$ (goethite) which it might well have been, it would have been 63% Fe_2O_3 . Merely drying a ferric hydroxide precipitate will leave some water; a better figure for the iron is derived by combining Experiments I and II, subtracting 12% gangue from the 75% residue of Experiment I which gives 63% Fe_2O_3 , containing 44% iron, which if present wholly as pyrite would need $50\frac{1}{2}\%$ sulphur. If we accept 12% gangue and 44% iron we could have 44% sulphur by difference; and if part of the iron is present as magnetite, or pyrrhotine, or both, the 6% difference is not serious. In fact, the analysis could be interpreted as (assuming no magnetite,—pyrrhotine being magnetic):

gangue	12%
pyrite (FeS_2)	71% = 33% Fe, 38% S
pyrrhotine (Fe_7S_8 — FeS)	17% = 11% Fe, 6% S
	44% iron 44% sulphur

Experiment V. These seventy grains were heated in six ounces of distilled acetic acid [*azijn*]; the undissolved parts isolated by filtering, and the acetic acid [*azijn*] evaporated until dry; diluted sulphuric acid [*zwavel-zuur*] was added, in order to separate the possibly present calcareous earth [*Kalk-aarde*] from the Magnesia [*Magnesia*]; the undissolved parts, which were selenite [*seloniet*] weighed dried *two* grains; and from the liquid, diluted with distilled water, were precipitated by plant alkali [*planten loogzout*] three grains of Magnesia (*Bitteraarde*).

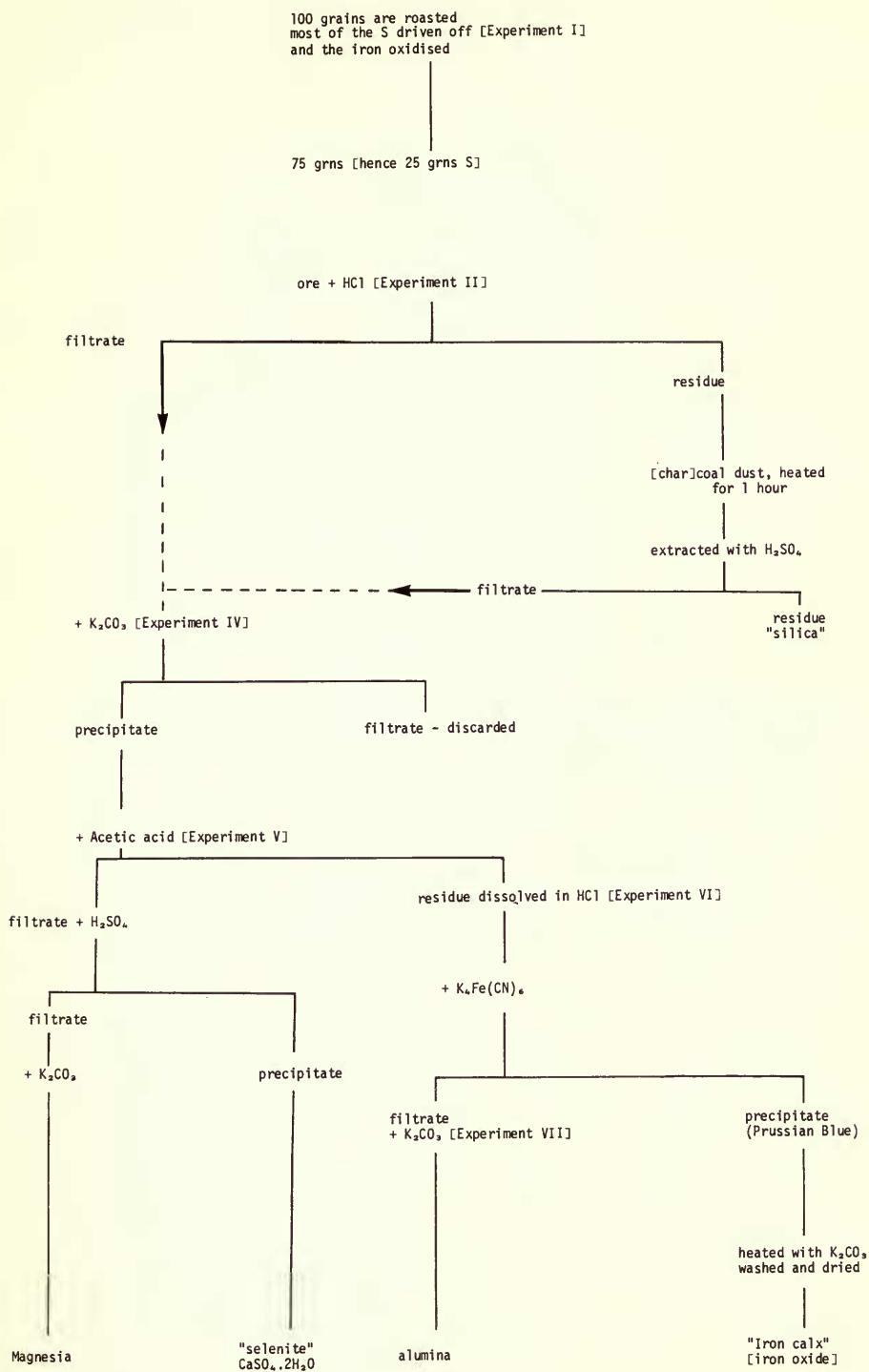


Fig. 3 A flow diagram illustrating Horsfield's analytical scheme of a pyrite/pyrrhotine ore.

Experiment VI. After heating with acetic acid [*azijn*] the undissolved parts (the last experiment) were dissolved in hydrochloric acid [*zeezout zuur*] and diluted with water; Prussiate of potash [*blaauw zuur loog zout*] was added until no more precipitation had taken place; the precipitate was separated by filtration and heated with plant alkali [*planten-loogzout*]; the well washed out and dried Iron-calx [*Yzer-kalk*] weighed *forty-nine* grains.

Experiment VII. From the filtered liquid (of the Sixth Experiment) were precipitated by the plant alkali [*planten-loogzout*] six grains of alum-earth [*Aluin-aarde*].

According to these experiments 100 grains of Massoerong consist of

25 grains of sulphur [<i>Zwavel</i>], Experiment I.	[25%]
49 grains of Iron-calx [<i>Yzer-kalk</i>], Experiment VI.	[49%]
23 grains of Earthy (terreous) parts [<i>Aardachtige deelen</i>], Experiments II, V and VII.	[23%]
3 grains (by loss)	[3%]
100 grains.	

[At the date of this work, it was not commonly realized that in sulphides the sulphur is combined with a metal, not with a metallic oxide; hence Horsfield assumes that the 25% loss of weight in Experiment I is sulphur whereas in fact 44% of sulphur has been lost and replaced by 19% oxygen;

the two reactions are: Pyrite $4\text{FeS}_2 + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3 + 8\text{S}$
 Pyrrhotine $4\text{FeS} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3 + 4\text{S}$

Horsfield's mineralogical map of Java

Horsfield intended that his paper 'On the mineralogy of Java' (1816a) should be accompanied by a mineralogical map of the island, but what he compiled for the purpose was adjudged insufficient for publication (Horsfield *et al.*, 1838–52, Postscript: ii, footnote). The map in question may possibly be that in Horsfield's hand in the India Office Library and Records, London. It is, in any case, to be doubted if the Government Press at Batavia which printed his paper had the technical apparatus at that time to produce such a map. It was therefore only with the publication in London of the large map of the island in Raffles' *The history of Java* (1817) that there appeared as a modest inset Horsfield's 'Mineralogical sketch of the island of Java', dated 1812. (Fig. 4). It was later reproduced (also in colour) with lettering in French in Fr. J. F. Marchal's *Description géographique, historique et commerciale de Java et des autres îles l'archipel Indien* (Brussels, [Paris], 1824–25).

The map was made at a time when geological maps were being prepared elsewhere. For example, the geological map of the United States by William Maclure (1767–1840) appeared in 1809 with a French translation in 1811 (White, 1977), and William Smith (1769–1839) published his large geological map of England in 1815. Earlier, Smith had produced two smaller geological maps, one of the Bath neighbourhood in 1799, and a simple geological map of England and Wales in 1801 (Eyles, 1969). Thus Horsfield's map was more or less contemporary with these⁸.

From a geological standpoint, however, there are differences between Java and England. Java is dominated by large, active volcanoes and their products. Sedimentary rocks are few and, with the exception of some Mesozoic sediments, are Tertiary in age or younger. Hence we cannot expect a geological map of the same type as Smith's with the representation of England's fossiliferous sedimentary strata. Horsfield did comment on fossils at, for example, his locality 8, where he noted that the stone contained shells. Apart from rocks containing microfossils, which Horsfield would not have known about, he collected other fossiliferous specimens, most notably at his localities 117 and 177 (see catalogue). But in the main he was silent on stratigraphical and palaeontological considerations. Inevitably, lavas predominate both on his map and in his collection. Horsfield's mineralogical map was therefore well named. Unfortunately techniques did not exist at that time for examining lavas. Nor had our contemporary mineralogical classification

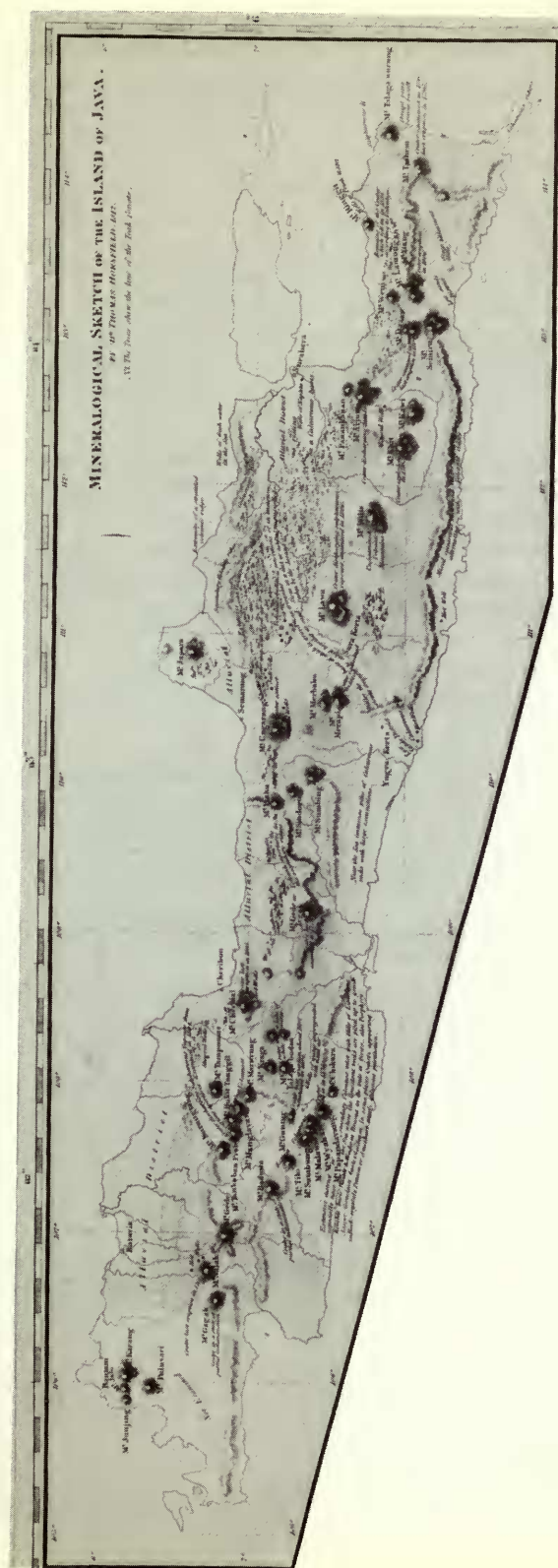


Fig. 4 'Mineralogical sketch of the island of Java. By Dr Thomas Horsfield, 1812.' An inset on the map of Java in T. S. Raffles' *History of Java* (London, 1817).

of rocks been produced; this had to wait until the 1850s when there came about improvements in the petrological microscope, and, as important, a technique for making thin sections of rocks.

Whatever its limitations, Horsfield's map held its position for more than thirty years, largely because the early members of the Natural Sciences Commission in Indonesia devoted their principal attention to botany and zoology, with a consequent neglect of geology and mineralogy. This situation was eventually remedied with the arrival in Java in 1835 of F. W. Junghuhn who, in a series of articles during the 1840s, in his *Topographische und Naturwissenschaftliche Reisen durch Java* (Magdeburg, 1845), and most notably in his *Java, zijne gedaante, zijn plantentooi en inwendige bouw* (Amsterdam, 1850–53; The Hague, 1853–54), revolutionized the study of Indonesian geology and vulcanology. In the latter work Junghuhn explicitly states that his principal aim was to draft, on the basis of the labours of Horsfield and Raffles, an improved location map of the volcanoes of Java. He noted one or two inaccuracies in Horsfield's mineralogical map (the omission of G. Raung and the representation of G. Idjen by the word 'Tashem') and then went on to pay the following remarkable tribute to his American predecessor (Junghuhn, 1853–54, I:98–99):

One must do justice to the man, to admire the tenacity of him, who in an age when travelling in Java, namely from 1800 to 1812 [*sic*], was attended with so many greater difficulties than at present, assembled such complete materials for such a comprehensive work, for a work, that, relative to Java, may be taken as the first of its kind. Th. Horsfield was the *first* naturalist who made his way through the age-old forests of Java and at the same time the first who has investigated and described the island from a geographical-geological point of view.

Horsfield paid his own tribute to the German naturalist in 1852 (Horsfield *et al.*, 1838–52, Geographical Preface:ii–iii), after the publication of Volume I of Junghuhn's *Java*, containing a hypsographical representation of all the island's volcanoes:

As a proof of extent of research, perseverance of labour, skill and ingenuity of construction, it is, in my opinion, unequalled by any similar representation of a volcanic range. This work is the result of many years' research in Java, during which every individual of the series of volcanos, forty-six in number, with a single exception, was ascended, examined, described and illustrated by many local maps, diagrams, views of craters and profiles.

He went on to amplify Junghuhn's corrections of his mineralogical map and to explain the circumstances of its compilation (Horsfield *et al.*, 1838–52, Postscript:iii, n.*):

In the paper referred to ['Essay on the mineralogy of Java' (Horsfield, 1816a)] it was my object to give a general, though necessarily imperfect enumeration of the series of volcanos, extending from west to east, through the whole island. At the same time I had compiled hastily a geological sketch, which was not sufficiently correct for publication. It may therefore be useful on this occasion to explain several mistakes and omissions which have been noticed, especially in the eastern division: namely the name of the Mountain Raon [G. Raung] has been omitted, and the name of Mount Ijen [G. Idjen] has been incorrectly engraved Tashem.

Catalogue of rock specimens collected by Horsfield in Bangka

Horsfield left Batavia for Bangka on 1 November 1812 aboard the brig *Minerva* (Captain M. Holmes) accompanied by Colonel J. Eales, Resident and Commandant of Palembang and Bangka, Captain J. Hanson, a draughtsman, assistant, Indonesian collectors, and a body of troops. Ill-health soon began to affect the British garrison on the island and Horsfield was obliged to act as surgeon. In this connection he established a modest hospital in what was regarded as a healthy neighbourhood near the village of Ranggam, to the east of Muntok. Both Eales and Hanson were forced to return to Java because of sickness and the former was succeeded by Major W. Robison. After consultation with him Horsfield began a botanical, zoological and geological collecting tour of the island in March 1813.



Fig. 5 Mineralogical map of the island of Bangka, by Dr Thomas Horsfield, in the India Office Library, London.

In accordance with his instructions (Lady Raffles, 1830:607), Horsfield paid particular attention to the tin deposits in the island and tin extraction by the Chinese. Geologically Bangka is more similar to Peninsular Malaysia and Pulau Belitung than to its near neighbour Sumatra, the ore-producing zone running from Peninsular Malaysia through Bangka and Belitung to south-west Borneo (Katili, 1974). The island is composed of Triassic sediments and lavas, with some granites (Jackson, 1969), and Horsfield noted that the highest points of the island were granite but that the ore was often found in horizontal, sedimentary strata.

After his return to Java in July 1813 Horsfield prepared a long report on the geography and geological structure of the island for Raffles who in 1817 proposed that it should be worked up into a book entitled *An account of the island of Banca, in the East Indies*. For various reasons, this work was not completed, and it was only in 1848, as a result of the endeavours of J. R. Logan, editor of the *Journal of the Indian Archipelago*, that Horsfield's original report was published in that periodical, a Dutch translation appearing in the *Tijdschrift voor Nederlandsch Indië* between 1850 and 1852 (Horsfield, 1848).

Even before Horsfield left Bangka some of his botanical and geological specimens were lost for he records (Lady Raffles, 1830:611) how his draughtsman was killed in a scuffle with Indonesians and many of his specimens destroyed. Unfortunately, what remained of his Bangka geological collection no longer survives. It is clear from records formerly at the India Museum and now in the Mineralogy Department Library, British Museum (Natural History), that the collection was at Fife House, London, during the 1860s; but if, at the final dispersal of materials of the India Museum in 1879, the collection was given to the Royal School of Mines, enquiries there have failed to trace it.

There are three versions of Horsfield's catalogue of geological specimens from Bangka in the India Office Library and Records, London (*MSS. Eur. F. 53*). One is written by Horsfield and one by his usual scribe. The third document is a description of the localities written by the scribe and is entitled 'Section II Mineralogical descriptions of the Island'. In all, two hundred localities were visited on the northern part of the island, and their locations are marked on the map which Horsfield made, and which was subsequently engraved. This collection is better documented than Horsfield's collecting localities in Java so that it is all the more unfortunate that the Bangka collection is now lost.

Catalogue of rock specimens collected by Horsfield in Sumatra

Much is known about Horsfield's activities in Sumatra during 1818 when he travelled with Sir Stamford Raffles and Lady Raffles from Padang on the west coast to Pagarruyung. He left Padang on 14 July with an advance party of coolies, two days before Raffles and Lady Raffles, and they met up again on 17 July at the toll post beyond Limaumanis. The bed of the river there 'afforded a fine opportunity for collecting specimens of minerals . . . principally of volcanic origin' (Lady Raffles, 1830:345), and on 18 July further specimens were collected between there and P. Campeda (Catalogue Nos. 2(?), 5). On 21 July at Saningbakar Horsfield collected in localities 12, 18–19, and 22. On 22 July the party crossed the Singkarak lake and reached Simawang, where Raffles records having found 'felspar, granite, quartz, and other minerals of a primitive formation . . . mixed with a variety of volcanic productions in the greatest confusion . . . Dr. Horsfield got specimens of these, which he gave in charge of some coolies who attended him; after a day's journey he wished to examine this collection; the men produced their baskets full of stones, but on the Doctor's exclaiming they were not what he had given them, and expressing some anger on the occasion, they simply observed, they thought he only wanted stones, and they preferred carrying their baskets empty, so they threw away what he gave them, and filled them up at the end of the day's journey, and they were sure they gave him more than he collected' (Lady Raffles, 1830:357). Catalogue Nos. 23–29 were collected near Simawang, and Nos. 42–43, 45, and 52–53 at Suruaso and Pagarruyung on 23–24 July. On the return journey No. 56 was collected on 27 July at Peninggahan on the western side of Danu Singkarak, and Nos. 59, 60–63, and 67 between 27 and 30 July in localities from Peninggahan and Pinang. The party arrived back at Padang on 30 July and Catalogue Nos. 69–71 were collected from Padang Head on that or the



following day, when the ship *Lady Raffles*, with Horsfield, Raffles and Lady Raffles on board, sailed on the return voyage to Benkulen.

Altogether seventy-one specimens from Sumatra are listed in Horsfield's catalogue in the India Office Library, London, but the catalogue printed below represents only a selection of rock specimens from Sumatra made by Horsfield after his return to Benkulen on 3 August 1818 for C. M. Ricketts (1776–1867) in Calcutta. The latter was a cousin of Lord Liverpool who had served as Secretary of the Public Department and later of the Political and Commercial Department in Calcutta before becoming a member of the Bengal Council in 1819. He was a Fellow of the Geological Society of London and after 1820 a Fellow of the Royal Society. Judging by a letter which Horsfield wrote from Benkulen to John Fendall (1760–1825) on 18 August 1818, on the eve of his departure for Java, Ricketts had requested geological specimens from Indonesia and these were now despatched to Calcutta via Fendall, who had been Raffles' successor as Lieutenant-Governor of Java in 1816, and who was personally known to Horsfield:

Respected Sir!

I have made a small selection of mineralogical specimens from the collection we made during our excursion to Menangkabu agreeably to the memorandum of Mr Ricketts enclosed in your letter, which I request you to present to that gentleman with my respectful compliments. I have added a catalogue, corresponding to the numbers of our mineral catalogue. Should it be in my power of ever returning to Java, I will supply you with a similar selection of descriptive geological specimens from that Island.

I have the honour to remain

Respect Sir

Your obedient & obliged servant,
Thos Horsfield

This collection is now in the British Museum (Natural History), with the above letter, having been presented by the Geological Society in 1911 in circumstances outlined by Campbell Smith (1928) and Moore (1982). It seems likely that the Geological Society came into possession of the collection from Ricketts during the 1820s, probably before he was appointed Consul-General to Lima in 1827. In any event, this sub-collection is all that remains of the rock specimens collected by Horsfield in Sumatra, and is for that reason of particular interest. As the collection was registered at the British Museum (Natural History) in 1911 the numbers bear little relation to those of the Java collection.

Catalogue of descriptive mineralogical specimens for Mr Ricketts Esq

2. *Amygdaloid from Gedong beo*
[BM 1911, 1350 (1), weathered amygdaloidal lava. Collected 17/18 July 1818.]
5. *Trappian stone separating in rhomboidal and parallel fragments found between Gedong beo and Pulo Champedda*
[BM 1911, 1350 (2), slightly weathered granite gneiss or granite. Collected 18 July 1818.]
8. *Amygdaloid from a volcanic plain called Danu tega-[blas?]*
[BM 1911, 1350 (3), agglomerate.]
9. *Pebbles of various kinds; from the same place*
[BM 1911, 1350 (4), weathered granitic rock.]
12. *Obsidian found between Solok and Sindang-baker*
[BM 1911, 1350 (5), obsidian. Collected 21 July 1818.]
18. *Pumice from the lake or Danu at Sindang-baker*
[BM 1911, 1350 (6), pumice. Collected 21 July 1818.]
19. *Cellular rock; approximately composed of quartz and hornblende from the borders of the lake at Sindang-baker*
[BM 1911, 1350 (7), a siliceous deposit with a mantle of quartz crystals. Collected 21 July 1818.]
22. *Pebbles from the borders of the lake on the west side near Sindang-baker*
[BM 1911, 1350 (8), amygdoidal weathered lava. Collected 21 July 1818.]

23. *Pebbles from the borders of the lake on the east side near Semawang*
[BM 1911, 1350 (9), altered quartz porphyry. Collected 22 July 1818.]
24. *Impure limestone mixt with particles of [illegible] rock. From the eastern borders of the lake*
[Specimens missing]
25. *Imperfect granite from the activities of the hill between the landing place and the village of Semawang*
[BM 1911, 1350 (10), plagioclase-quartz-muscovite schist. Collected 22 July 1818.]
26. *Fragments of rock consisting of Quartz and Feldspar the latter of a greenish color. From the same hill—See No 25*
[BM 1911, 1350 (11), greenish quartz-epidote rock. Collected 22 July 1818.]
27. *Fragments of rock of Quartz and Feldspar—the latter of a reddish color—(See No 25) from the same hill*
[BM 1911, 1350 (12), reddish quartz-bearing rock. Collected 22 July 1818.]
28. *Ochreous brown Iron Stone; passing into decomposed Granite and into a yellow ochreous deposition from [water?]*—*From the same hill (See No 25)*
[BM 1911, 1350 (13), contorted quartz-muscovite schist. Collected 22 July 1818.]
29. *Iron-ore—From the summit of the hill See No 25—near the village*
[BM 1911, 1350 (14), dense quartz-bearing sedimentary ironstone with pyroclastic components. Collected 22 July 1818.]
35. *Iron-ore—From Gunning-bezi near Semawang*
[BM 1911, 1350 (15), ironstone similar to the above. Collected 22 July 1818.]
42. *Amygdaloid [added later: and sandstone] varieties of this substance from the hills between the northern banks of the Indragiri river and Suruwasa*
[Two specimens. BM 1911, 1350 (16), medium to coarse-grained lithic sandstone with a ferruginous cement. BM 1911, 1350 (17) is coarse yellow conglomerate. Collected 22 July 1818.]
43. *Varieties of Sandstone and stone of aqueous deposition. From the same hills (No 42) found in conjunction with the amygdaloid*
[BM 1911, 1350 (18), tuff.]
45. *Feldspar and imperfect granite—Found between Indragiri river and Surawasa*
[BM 1911, 1350 (19), a yellow quartz-muscovite-bearing greywacke. Collected 23 July 1818.]
52. *Pebbles. From the bed of the river Sungi-mas at Pagaruyung. Note most of these pebbles are basaltic and trappean; but with them are mixt others of a very compact and imperfect Granite following much of the character of Syenite, which indicate the continuation of the trappean and primitive parts of Sumatra towards the source of the river*
[Two specimens. BM 1911, 1350 (20), a leucocratic gneiss. BM 1911, 1350 (21) is andesite. Collected 24 July 1818.]
53. *Quartzose Iron-ore From the bed of the same river—see No 52*
[BM 1911, 1350 (22), ferruginous stained white quartz. Collected 24 July 1818.]
56. *Fragments of primitive rock consisting of Granite passing into gneiss and micaceous schistus found in great abundance on several of the first [ascents] from the lake at Pininggahan towards Gedong Pappau and bounded by extensive masses of Marble and Limestone*
[BM 1911, 1350 (23), calcite-sericite-bearing metamorphosed pyroxene andesite. Collected 27 July 1818.]
59. *Limestone/Marble/between Paninggahan and Gedong beo*
[BM 1911, 1350 (24). This specimen is labelled 60 on the rock which is a limestone with a calcite vein. There is no specimen 59.]
60. *Calcareous spar—From the same place (59)*
[No specimen, see above. There is a specimen 61 which is BM 1911, 1350 (25) and is a crystalline limestone. Probably collected 27 July 1818.]
62. *Cellular Limestone. From the same route (59)*
[BM 1911, 1350 (26), calcareous breccia or concretion.]
63. *Slaty limestone. From the same route (59)*
[BM 1911, 1350 (27), quartz-bearing limestone. Collected 27 July 1818.]



Plate 5 Two of Horsfield's geological specimens from Indonesia. *Left*, part of a Miocene crustacean (? Xanthid, crab) from Java (Horsfield's Java catalogue 177). *Right*, a cluster of quartz crystals from Padang Head, Sumatra (Horsfield's Sumatra catalogue 69).

64. *Fragments of Granite and trappean pebbles from the river of Gedong pappau*
[Two specimens. BM 1911, 1350 (28), muscovite granite fragment. BM 1911, 1350 (29) is a leucogranite. Collected 27 July 1818.]
67. *Stone of watery deposition from the ridges between Sambung and Pinang*
[BM 1911, 1350 (30), an altered tuff. Collected 29 July 1818.]
69. *Rock crystal from Padang head*
[BM 1911, 1350 (31), a cluster of quartz crystals. Probably collected 30 July 1818. Illustrated in Plate 4.]
70. *Calcedony, trap &c from Padang head*
[BM 1911, 1350 (32), three small cherty pebbles. Collected 30 July 1818.]
71. *Iron Pyrites—from Padang head*
[BM 1911, 1350 (33), a sample of small cubic crystals of pyrite. Collected 30 July 1818.]

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Notes

1 There is abundant information on Timothy Horsfield Sr and the Moravian Church in the United States in Jordan (1909a) and Yates *et al.* (1968). Timothy Horsfield Sr was involved in the building of the Moravian immigrant ship *Irene* at Staten Island in 1744–48.

2 The Moravian Church had its origins in Czechoslovakia in late Medieval times. It was forced underground after the Thirty Years War in Europe (1618–48), but revived in Germany, the Netherlands, and to some extent England, as a result of the patronage of Count N. L. Zinzendorf (1700–1760) in the eighteenth century. Timothy Horsfield Sr (see Note 1) was the friend of two Moravians of note, David Nitschman (1696–1772) and Peter Boehler (1712–1775). John Wesley (1703–1791), attributed his own conversion to Boehler during the 1730s.

3 Horsfield's collection is not the only Indonesian geological collection of this period in the British Museum (Natural History). Captain Basil Hall (1788–1844) R.N., son of the pioneer experimental mineralogist Sir James Hall (1761–1832), collected in Java in 1816.

4 Horsfield's appointment to the Museum of the English East India Company was influenced by a letter of recommendation sent by Raffles to the Directors of the Company (Lady Raffles, 1830:629), and his cordial reception in London was due to other letters of recommendation which Raffles addressed to members of the scientific community in the capital, including one to Sir Joseph Banks, President of the Royal Society (*DTC*, 20, fols. 105–07, letter dated 14 August 1818).

5 Also buried at Chelsea is Peter Boehler (see Note 2).

6 Horsfield had read widely on geological matters of his time. In addition to the writings of Werner and De Saussure we know that he was familiar with E. D. Clarke's *Travels in various countries of Europe, Asia, and Africa*, London, 1810–23 (see Note 7). He had also read Sir George Steuart Mackenzie's *Travels in the island of Iceland, during the summer of the year MDCCCX*, London, 1811 (Horsfield, 1816b:108).

7 Horsfield's reference to Pallas and Clarke is interesting. Professor T. G. Vallance has drawn our attention to the fact that Clarke in his *Travels* mentions mud volcanoes in southern Russia. A possible explanation is set out below and if correct, confirms our view that Horsfield was well read (see Note 6):

P. S. Pallas (1741–1811) in English translation from German (*Travels through the southern provinces of the Russian Empire, in . . . 1793 and 1794*, London, 1803, II:319–30) refers to a mud volcano called Kuuk-Obo or Prekla on the east shore of the straits separating the Sea of Azov and the Black Sea. Pallas records that on 27 February 1794 smoke and flame burst from this area followed by streams of boiling mud, which he later examined. E. D. Clarke (1769–1822) visited the area some ten years after Pallas on his Russian journey (*Travels in various countries of Europe, Asia, and Africa*, London, 1810–23, I:409) and commented on the phenomenon.

From a geological standpoint, mud volcanoes are known to be associated with diapiric structures in oilfields and gas seepages. The area described by Pallas and Clarke is an oilfield, and, interestingly, Pallas refers to an eyewitness account of March 1794 to the effect that vapour and mud mingled with rock-oil was still ascending. There is thus reason for thinking that the mire wells of Pallas and Clarke are associated with hydrocarbon seepage.

8 Mineralogical maps were produced in the eighteenth century in France, England, Germany, Russia, and Sweden. (For discussion see V. A. Eyles, 'Mineralogical maps as forerunners of modern geological maps' *The Cartographic Journal*, December 1972, pp 133–5. This is a reprint from *Geologie* 20 of 1971.) An important difference between a mineralogical map and a geological map is that the age of the rock is an important consideration in geological maps.

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